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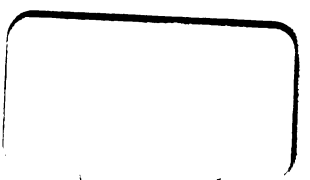

REPORT

OF THE

CHIEF ENGINEER

OF

CANALS.

OTTAWA, 1880.

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No. 52,200.

OFFICE OF THE MINISTER OF RAILWAYS AND CANALS,

CANADA.

OTTAWA, 8th November, 1879.

DEAR SIR:

I observe that you have not submitted a general report on the Canals under your charge since January, 1877; and, as I am desirous to lay before Parliament, at its next session, a comprehensive view of the enlargement of the St. Lawrence and Welland Canals, as well as the Canals on the Ottawa River, etc., I have, therefore, to request you to prepare and have printed a full report on these important improvements by the 1st day of February next.

In doing this you will please describe the different works, the progress that has been made, and what remains to be done to complete the various undertakings; and I may add that it is important that this should be done in a manner to be clearly and readily understood.

Yours faithfully,

CHARLES TUPPER.

JOHN PAGE, Esq., C.E.,
Chief Engineer Canals,
Department of Railways and Canals,
Ottawa.

REPORT

OF THE

CHIEF ENGINEER OF CANALS.

OTTAWA, 16*th February*, 1880.

The Honorable

Sir CHARLES TUPPER, K.C.M.G., C.B.,

Minister of Railways and Canals.

SIR:

I duly received your letter of the 8th November last (copy prefixed), directing a general report to be prepared on the works of enlargement and the improvements in progress on the various canals under the control of this Department, embracing, where necessary, the main navigable channels between which they form connecting links.

On receipt of these instructions, the principal Resident Officers on the different works were requested to furnish such useful information as had come under notice in the course of the discharge of their respective duties. Copies of several of the documents received from them are hereto appended.

It is considered proper to invite attention to my previous special reports on this subject, in case the endeavor to avoid repetition may have led to a

less degree of clearness than might have resulted from greater freedom of treatment.

It is, no doubt, within the knowledge of the Department that, when the enlargement of the canals was decided upon in 1871, the scale of navigation on the St. Lawrence route was, throughout, fixed at an available depth of twelve feet of water. On this basis the necessary surveys and examinations were made, and schemes for the enlargement of the different ranges of works were, in each case, submitted for consideration and approval, and in 1873 they were authorized to be carried out. In 1874, however, many intelligent practical business men, as well as numerous public bodies, fairly entitled to be heard, turned their attention to the subject, and, in the early part of 1875, strong representations were made of the desirability of having the different channels sufficiently deepened to admit of the passage of vessels drawing fourteen feet of water.

This, after a time, was assented to by the Government, and orders issued to have the foundations of all permanent structures, on those parts of the works not then under contract, placed at a depth corresponding to fourteen feet of water on the mitre sills of the locks.

Under these directions, the works on the Lachine, Cornwall and Welland Canals have been proceeded with. The necessary instructions were first given in relation to the latter, but were subsequently extended to all the principal works on the main line of navigation between Lake Erie and the City of Montreal.

In this distance (375 miles), there are seven different stretches of canal, having in the aggregate a length of about 70½ miles, on which there are 53 locks. Six of these are guard locks, at the different upper entrances, for the regulation in each case of the reach below them at periods of high water in the river or lakes. The total height overcome by locks is 533½ feet. Lake Erie is, however, 550¾ feet higher than the river at Montreal; the difference between the lockage and the actual height of the water (17½ feet) is accounted for by the inclination of the surface of the river and lakes.

The locks on the enlarged canals are to be 270 feet long between the gates, 45 feet in width and, when completed, are to have a depth of 14 feet of water on the sills.

This will enable vessels of almost any ordinary build to pass, carrying fully one thousand tons burden; but, as the tendency seems to be towards increasing the breadth of beam and sectional area of freight vessels, it is probable that the canals will ere long be navigated by a class of vessels capable of carrying fully 1,500 tons. Lake Ontario and the River St. Lawrence will then be accessible to a large and profitable class of vessels, now in use on the Western Lakes, connections with which have enabled the Erie Canal to hold its own successfully for the carrying of heavy freight, so that in 1878 and '79 more tonnage was moved eastward upon it than in any two previous years. If, therefore, a long artificial water route of limited capacity could thus, not only resist, but make headway in the face of the opposition of powerful railway companies, it seems fair to infer that the superior advantages which the Canadian route will offer should be attended with even better results.

If the actual owners of railways, undertaken for profit, were in reality the managers of them, it is probable that competition would seldom result in rivalry to the extent it is alleged in some cases to have done, there being good reason to believe that stockholders would be quite as likely to feel interested in a fair dividend as in crushing or absorbing a friendly competition; especially as they, the original promoters, have, in many instances, long looked in vain for any returns on their investments, and even the claims of second and third preference bondholders have been scarcely recognized and, in some cases, wholly ignored.

This state of matters, it may be fairly presumed, cannot always continue; structures require renewal; rails and rolling stock wear out; whilst freight carried either at or below cost, must, under the circumstances, lead to embarrassments of no ordinary nature. It is therefore believed that such anomalous ways of doing business must eventually come to an end, and lead to the introduction of a system tending more to the interests of those who supply the means than to sheer antagonism to others engaged in similar pursuits.

The real competition between rail and water lines commences at the east or lower end of Lake Erie, a fact recognized by several of the trunk lines of railways, who, instead of continuing a ruinous competition with the large class of vessels engaged in the grain trade between western and eastern ports, now run from the latter places in connection with them, thus, in a measure, foreshadowing the result of what will in all probability take place when the line of the Canadian canal improvements has been completed, which will practically extend ocean navigation to the head of Lake Superior, Chicago and all other western lake ports; a result that, taken in connection with the comparatively short time in which the round trip can be made, would seem to place the St. Lawrence line

of navigation in a position to successfully compete with any known freight route for the trade between the grain-producing countries of the West and the Atlantic seaboard, besides opening up accessible markets for the extensive coal-fields of Nova Scotia.

WELLAND CANAL.

This important part of the main line of inland navigation, since its first inception, has, like most other great undertakings, passed through various stages of development, a brief outline of a few of which may, it is believed, be found sufficiently interesting to be again brought under notice.

Upwards of 60 years ago, when what is now the Province of Ontario was comparatively new, a few far-seeing individuals undertook the extremely difficult task of convincing others of the advantages the country would derive from connecting Lakes Erie and Ontario by means of a canal. Nothing short of the well-directed, unyielding efforts of a man possessing the peculiar characteristics of the late Hon. William Hamilton Merritt could have been at all successful in pressing forward so great an enterprise in the face of the limited public interest taken in the project, and the still more limited prospect of obtaining the necessary funds.

The construction of the canal was, nevertheless, commenced by an incorporated company in 1825, who, besides being often unable to meet their liabilities, encountered many unforeseen difficulties that rendered frequent changes in their plans imperative. Amongst the rest were slides, or displacements of the sides and, to a great extent, the filling up of the cut formed through the summit or highest ridge of land on the line adopted for the canal, then, as now, called the Deep Cut.

This unanticipated difficulty led to the abandonment of the original design of using the Welland River as a feeder, and to the adoption of a plan for drawing the water supply from the Grand River at a point about five miles above its outlet. At this place, now the town of Dunnville, the water was raised by means of a dam, and from it a continuous channel or feeder 27 miles in length was cut to Port Robinson, at an elevation of about 15½ feet higher than the summit level first contemplated. This, to a like extent, diminished the depth of excavation through the ridge and increased the probability of the banks standing.

These changes, unavoidable at the time, greatly increased the financial embarrassment of the company and compelled them to resort to every possible means of raising funds to carry on the undertaking, in which they so far succeeded that two vessels were taken through the canal from Lake Ontario to the Welland River at Port Robinson in November, 1829.

The monetary affairs of the company were at this time in a most perplexing state, which induced them to renew their efforts to obtain further assistance from the Government. Their representations eventually resulted in a grant being made, subject to certain conditions, one of which was the extension of the canal southward to Lake Erie, on nearly the same line as it now occupies, an arrangement that was untimately carried out, and that part of the route opened for the passage of vessels on the 20th May, 1833.

The channel thus brought into use was narrow throughout, and the locks upon it were 100 feet long and 22 feet wide, except those at the immediate entrances, which were larger. All of them, as well as most of the other structures, were built chiefly of wood, put together in the least expensive way that the circumstances would permit.

No further improvements were undertaken by the company, who found that, from the nature of the works constructed on the line, they were subject to frequent casualties, resulting in a constant large outlay for maintenance. This, together with their other financial troubles, rendered it quite evident that they could not maintain the canal in that efficient condition which its importance demanded. Having become thoroughly convinced of this, and being desirous of obtaining relief from their difficulties, the company pressed the Government to assume the entire control of the undertaking, which, after a time, was acceded to, and an Act passed by the Legislature in 1841 authorized the purchase of the rights of the private stockholders.

The management of the canal was shortly afterwards transferred to the then newly-appointed "Board of Works."

At that time there stood against it in the books of the Province the sum of $1,851,427.27.

In September, 1841, an appropriation was granted towards the enlargement and improvement of the line, and for making the structures upon it of a permanent character. It was then understood that all the new locks were to be of stone; those in the interior 120 feet long, 24 feet wide, with 8½ feet of water on the sills; the locks at the different entrances were to be 200 feet long, 45 feet wide, and have 9 feet of water on the sills. The aqueduct required to carry the canal over the Welland River was also to be built of stone.

The works of enlargement were commenced in 1842, Port Colborne on Lake Erie, and Port Dalhousie on Lake Ontario, being still kept as the entrances to the main line; but at the latter place the site for the harbor was changed from the west side to opposite the east side of the valley of the Twelve Mile

Creek. A dam was made a short distance above, which, together with the outlet lock keeps up the reach, for about 3 miles, to St. Catharines. This water stretch is wide, and at many places deep, forming as a whole a large, convenient and safe inner harbor.

At St. Catharines, and above it, the crooked line of the old canal was followed to about the 10th lock, except at places where changes were made to secure more advantageous sites for the locks.

At the latter place a slight deviation was made to the westward for some distance, when a south-easterly, then a more southerly course was taken, winding gradually around the ascending ground until it nearly coincided with the old line through the Town of Thorold; thence southward, the old tortuous line through the valley of the Beaver Dams Creek, was followed to Allanburg, where the lift lock and approaches to it were placed a little more to the westward.

The same line through the Deep Cut was continued, but a new channel was formed across a prominent point at Port Robinson; and from what is now the Town of Welland, to the junction of the feeder with the main canal, a line was formed more to the eastward.

After considerable discussion on the various matters connected with the subject, it was decided in 1843 that the interior lift locks should be made 150 feet long between the gates, 26½ feet wide between the side walls and have a depth of 9 feet of water on the sills.

The entrance locks to be of the dimensions before stated, and the bottom of each of them laid at a depth to ensure 11½ feet of water on the sills at the lowest known stages of the respective lakes.

The bottom width of the straight parts of all the reaches was to be not less than 26 feet; but the summit level was to be made of such a sectional area that with side slopes of two horizontal to one vertical, the bottom should be 26 feet wide when sunk to a depth to admit of the water supply being drawn from Lake Erie.

Amongst the first works proceeded with in connection with the enlargement was the widening and deepening of the Feeder and the formation of the Port Maitland branch from it, together with the construction of a large lock down to the mouth of the Grand River at the level of Lake Erie.

The mountain range of locks below Thorold and the enlarged line of canal to the Junction, thence by way of the Feeder and Port Maitland branch, were all opened, throughout, in 1845.

All that part of the main line between the Junction and Port Colborne was then laid dry in order to admit of the channel being excavated to the required dimensions.

This course was then looked upon as indispensable—steam excavators and other equipment now found to be so well suited for that kind of work being then but little, if at all, applied to such purposes. Nevertheless, long-continued sickness amongst the laborers, and the failure of several firms of contractors, retarded the operations so much that this part of the route was not opened until the season of 1850. From the nature of the material through which the Deep Cut is formed, it was considered necessary in 1846 to make arrangements for increasing the water-way at that place to a width of 45 feet at bottom.

Frequent interruptions to the passage of vessels through the canal having been found to result from over-loading, to diminish the tendency to this objectionable course and, at the same time, enable the owners of vessels to derive as much benefit as possible from their property, it was decided in 1853 that the available depth of water in the canal, for navigable purposes, should be made 10 feet throughout.

This was effected by raising and strengthening the banks, where necessary, on all the reaches below Allanburg, and in a temporary manner increasing the height of the lock walls and gates. On the summit range of the canal there was then a sufficient depth for all purposes, the water being kept at, or within a foot of, Grand River level.

In 1854 it was decided that all the clay or earth parts of the summit level should be increased to a width of 50 feet at bottom. The channel through the rock cutting between Stonebridge and Port Colborne was previously made a mean width of about 57 feet.

From the foregoing it will be seen that opinions relative to the dimensions required for this canal, since its first inception, have been constantly changing and reasonably tending towards increasing its size. The enlargement commenced in 1842, the dimensions of which, fixed in 1843, *fully doubled* in capacity both the prism and locks of the original design; whilst the enlargement now in progress *more than trebles* the prism in sectional area, and the locks undertaken in 1843, in horizontal area.

Their respective tonnage capacities, it is believed, may be fairly assumed to bear a similar ratio to each other, *i.e.*, the tonnage of vessels that can pass through the canal authorized to be made in 1875, will be fully *six*

times greater than those that passed through the original canal, handed over to the Board of Works in 1841.

On the necessary surveys having been completed and all available information on the subject collected, a plan for the enlargement, on the scale then contemplated, was submitted in April, 1872, which was approved and authorized by the Government to be carried out.

This plan provided for the existing harbors at Ports Dalhousie and Colborne being continued as the respective entrances on Lakes Ontario and Erie for the enlarged canal; they, of course, in both cases, were to be enlarged, deepened and otherwise improved.

It was soon found that however desirable it might be to utilize the works of the present canal, the requirements of the enlarged scale of navigation would not admit this to be done between St. Catharines and the Town of Thorold, the objections being the winding course of the ravine and, at places, its narrowness, and in many cases the limited space between the different locks of the Mountain Range, it being then as now considered injudicious to build other than detached locks for the passage of large vessels.

It was also ascertained by subsequent surveys and examinations that a better and less expensive channel could be made between Thorold and Allanburg, than by following the tortuous line of the old canal through the valley of the Beaver Dams Creek.

These facts, although ascertained at different periods, led to the decision of forming an entirely new line to the eastward of the old one, starting from what is called May's Ravine, which is situated in the right bank of the Twelve Mile Creek, a short distance above Port Dalhousie, and connecting with the pond above the first lock; then continuing on upwards in the direction subsequently described, it strikes the line leading through the Deep Cut a short distance above the guard lock at Allanburg. Thence southward to Port Colborne the scheme of enlargement is either in progress or has already been effected by widening and deepening the old canal.

It may here be stated that the prism of the canal in long, straight reaches through earth or clay excavation, has a bottom width of 100 feet, with side slopes of two horizontal to one vertical; except through the Deep Cut, where the side slopes are two and a half horizontal to one vertical. In rock cutting the prism of the canal has the same sectional area as it has in ordinary clay excavation.

From the outer end of the entrance piers leading into the harbor of Port Dalhousie along the line of the new canal to Allanburg, thence to the outer end

of the entrance piers of Port Colborne Harbor, the distance is 26¾ miles, and the difference of level between Lake Ontario and Lake Erie at these two places in moderate weather is about 326¾ feet.

For the purpose of placing the works connected with the enlargement under contract, and the subsequent conducting of the operations, the line is divided into 36 sections, varying from half a mile to a mile in length, according to the extent and class of work upon them. For the superintendence of the different undertakings during their progress, it was considered proper to place them under the immediate charge of two resident engineers. Thomas Monro, an officer who had been a considerable time in the service, was detailed to the Northern Division, and W. G. Thompson was appointed to the Southern Division. After the surveys were made and the location decided upon, the duties of these officers consisted chiefly in the laying out of the works, and seeing them executed according to the plans, specifications and contracts sent them, and, together with their assistants, keeping correct records and measurements, etc., of the various kinds and items of work executed. It is gratifying to be able to state that these duties have been well and creditably discharged.

Under these resident officers, competent inspectors of masonry and of carpenters' work are invariably employed during the time the operations are in progress.

The Northern Division is 11.83 miles in length, forming 20 sections, which embrace all the masonry of the 25 lift locks and regulating weirs that are on the main line between the summit level and the lower outlet. On it there are the piers and abutments for twelve road bridges—piers and abutments for two railway bridges—six culverts to carry water-courses under the canal—one culvert for a public road to pass also under the canal—the construction of a tunnel and forming cuttings to and from it for a deviation of the line of the Great Western Railway.

This part of the line, which is entirely new, may be briefly described as follows:—Starting from the inner end of the piers, forming the entrance to Port Dalhousie Harbor, the line trends slightly toward the south-east, to where the new lock is situated in what was formerly a projecting point of high land, crossed by a public road; in this vicinity there was a dry dock, the site of which is now occupied by the canal works. Thence the line crosses a deep indent to the eastward, in the lower part of the upper inner basin, a distance of about 1,700 feet, to what is called May's Ravine, at the outlet of which the second lock is situated.

At this place the new line leaves the old canal and continues along the ravine to near the lower end of the third lock. At the upper end of the latter the canal again crosses the road between Port Dalhousie and St. Catharines. It then continues to curve gently round towards the south until about the fourth lock when it takes a straight south-easterly direction for fully four miles to about the eleventh lock. Between the fifth and sixth locks the line crosses the Welland Railway near the road-allowance, between the third and fourth concessions of Grantham; a little to the south of this the new canal is fully one mile and a half north-east of the old one. The continuous straight line above mentioned passes near the west side of St. Catharines cemetery and crosses the main road that lies on the north side of that place. At the eleventh lock the new line is about one mile and a half to the north-east of the old canal; near this place it curves to the south about twenty degrees, then continues straight for fully five-sixths of a mile. It then sweeps round to the south-west and ascends the rapid inclination near the foot of the escarpment, until near the twenty-second lock, where it winds round to the south and continues in that direction up through the ravine to the east of the Village of Thorold. Again curving to the south-west it passes through Marlatt's Pond, and a second time crosses the line of the Welland Railway.

In this vicinity the old and new canals are quite close to each other; the surface of the latter is, however, fully 4 feet over that of the pond or what is called the Allanburg level.

From the head of the twenty-fourth lock, situated in the ravine, to the head of the twenty-fifth lock, which is intended to maintain the upper level at its proper height, the distance is 5,812 feet.

This lock is placed as near to Marlatt's Pond as the securing of a proper foundation for it and the adjoining works would permit. By the adoption of this plan the summit level is brought about 2½ miles further to the north, and a new cut formed for that purpose up to the Holland Road, immediately north of Allanburg.

The course of the original canal is then followed until it intersects the line through the Deep Cut, at a short distance from the guard gates at that place, when the formation of an entirely new canal terminates.

The Southern Division is 14.94 miles long, and for the purpose of placing the works under contract it was arranged for 16 sections which, collectively, embrace the widening and deepening of the whole prism of the canal between Allanburg and Port Colborne. On it there is the masonry for the abutments

and piers of six road bridges, three railway bridges, a guard lock at Port Robinson, an aqueduct of large dimensions over or rather through the Chippawa River, a lock down to the Chippawa River at Welland, a syphon culvert to carry the water of Lyons' Creek through under the canal, and at Port Colborne a lock with four sets of gates, two heading each way, also a supply race in two divisions, one of which is arched and the other open, deepening and enlarging the harbor, entrance channel, etc.

From Allanburg, upwards, the enlarged channel follows the old line, the increased width being for the most part taken off the west side up to a point above Port Robinson, when it is in part, and in some cases wholly, taken off the east side.

From about a mile north of Welland to near the northern boundary of the Village of Stonebridge, the widening is altogether taken off the west side; at the latter place it partly comes off both sides until near the bridge, when it is again taken off the west side, and in this way continues through the rock cutting to near the corporation boundary of Port Colborne, where for some distance the line of widening continues gradually to increase towards the east until it is wholly taken off that side.

SECTION No. 1.

This part of the canal enlargement was, along with other sections, advertised in April, 1875, and tenders received in June following. After the adjustment of certain complications relating to it, the execution of the works was awarded to Patrick Larkin, who entered into contract on the 16th of October the same year.

The works on this section consist principally of the extension of the entrance piers 300 feet further into Lake Ontario, deepening the channel between them, increasing the extent of harbor accommodation and protecting the sides of the enlarged space by means of docking, the construction of a lift lock, up to what may be called the inner upper harbor, with its upper wings extended to form abutments for a road bridge and guide piers at the entrance, together with the extension of the weir in that vicinity to such dimensions as likely to discharge freely the surplus water from the canal, etc.

The entrance piers have a northerly and southerly direction, placed parallel to each other and 200 feet apart; the extension of 300 feet to the east pier embraces a head sixty feet square at the outer end, with a seat thirty feet square on it for a light-tower, made 6 feet higher than the adjoining superstructure. The seats for the cribs were prepared, and the channel sunk to the depth of 16½ feet below low-water line, as originally contemplated.

At the outer end of the pier a light-tower of a less height than the old one has been built, under the Marine Department; but, during the season of navigation, lights are exhibited in both, so as to form a fair range to vessels entering the harbor.

It was soon found that the addition to the east pier rendered necessary a like increase of length to the west pier, consequently an arrangement for that purpose was made in 1878 and the work done during the past season. The east pier now extends 2,460 feet, and the west one 2,210 feet into the lake beyond the line of the harbor proper. They are formed of crib work up to near the water surface, above which a continuous superstructure is carried up, and all the interior spaces are filled with stone ballast. The whole of them, except the 300 feet recently added in each case, were built at a time when dredging equipment for preparing the seats for piers was much less efficient than it is now.

This led frequently to sinking cribs on an uneven bottom, which often resulted in one side or one end settling down lower than the other, causing the side lines to be irregular, and occasionally leading to the vertical joints between two cribs being close at top but several inches apart at the bottom; at other places, to their being close at the bottom but with wide openings at top.

This condition of the under work of the piers is not attended with any bad results on the east side, but on the west side for a considerable distance beyond the line where a beach has been formed, the sand carried along by the surf is, during strong westerly winds, forced through the openings between the cribs and deposited in or alongside of the channel for a depth of fully 6 feet at several places. The irregular line of the crib work led to putting on the superstructure at some places, within this range and at other places projecting beyond it, thus leaving not only horizontal openings but preventing the back or west side from being sheeted in a manner to preclude sand washing through.

To meet the case it is proposed to drive a row of square, close piles parallel to the pier about four feet to the westward of it, and on the west side of the piles fasten a waling piece connected with the side timbers by ties a few feet apart, and afterwards fill the space between the piles and back of the pier with moderately fine gravel.

From the inner end of the entrance piers to the lower end of the new lock, a distance of about 1,700 feet, the entire space has been sunk to a depth of 15½ feet below low-water line, increasing the area of the harbor about eight acres and making it altogether of about 16 acres area, with ample width for the largest class of vessels to turn round in it freely.

Along the new part of the basin for a distance of fully eight hundred feet on the east side, and one thousand feet on the west side, crib work docking has been built where a large number of vessels can be moored safely when the weather outside is unfavorable for continuing their voyage.

In the docking on the west side a number of oblique openings are left to pass the surplus water from the canal, etc.

The new lock, as previously stated, is situated in what was a projecting high point of land on the right bank of the valley of the Twelve Mile Creek, at about five hundred and fifty feet to the eastward of the old canal, or one hundred and twenty feet east of the weir in use for the regulation of the water level.

On excavating the pit for the structure, rock was found from 6 to 30 inches over the bottom line; it is a reddish shale on top approximating to sandstone below, in thin layers irregularly stratified.

At the upper end of the foundation the rock suddenly disappears and the bottom being unusually soft, piles were driven, at a height suited to the bottom of the upper reach, to carry the walls connected with the pivot pier and the seat of the road bridge required there.

The rock at the north-west corner of the lock also dropped off at an acute angle, rendering an artificial foundation of some kind necessary at that place. After considering the matter as fully as could be done under the circumtances, it was decided to cut horizontal steps on the inclined edge of the rock, remove the soft material for several feet in depth to the extent required, and then fill up the space with concrete, made with hydraulic cement, kept in place, until fully set, by rows of oak piles.

This, together with other arrangements for security, it was believed, would fully answer the contemplated object, especially as the weight of the bank in rear would prevent the displacement of the bottom material.

The contractor having made the necessary preparations was desirous of proceeding with the building operations, and the bottom being rock, he was allowed to carry up the side walls at other places during the time that the arrangements at the north-east corner were in progress. When the latter were completed the wall at that place was rapidly built up to the same height as other parts of the structure.

The whole of the masonry was shortly afterwards carried up to near its full height; but the bank in rear of it, immediately opposite the defective part of the

foundation, was not made up until the following year. Consequently there was little or no weight outside the line of the wall to prevent the displacement of the bottom material. At all events the result has been a partial separation between that part of the west wall on the rock and the part north of it, leaving the vertical joints in a number of courses open, the width of which increases towards the top of the wall.

An attempt has been made to remedy this, which has been to some extent successful, but it is believed that still further overhauling of that part of the work will be necessary.

Above the lock the bottom was found to be of so unfavorable a nature that it was considered best to form the upper approach to it of crib work, a line of which has been extended on both sides for a distance of 240 feet above the seat of the road bridge.

In the specification for the works on this section (Appendix No. 1) it is provided that the old regulating weir is to be extended 50 feet or more towards the east, and that the new part is to be sunk 2 feet lower than the bottom of the old structure.

The peculiarities of the lock foundation having, however, brought to mind some of the difficulties connected with the construction of the original weir, together with the fact of it being rather unfavorably situated for extension, led to a decision in the spring of 1878 of making an entirely separate structure at a place about 300 feet nearer to the old lock, and the works connected with it were commenced early in September of that year.

It is what may be called a surface weir in two divisions, each 30 feet in width, with five different overfalls, and with water spaces 2 feet in depth between them. The bank in which it is placed forms the dam that keeps up the level above the lock; it is of considerable height and was made of material of a rather inferior class, for such a purpose.

There was, however, no choice of site in so far as the material is concerned; the whole being porous and spongy, a little below the surface, it became necessary to drive ranges of piles to carry the side, centre and cross walls, and to protect the entire area of the bottom from the direct action of the water.

The upper breast is about eighteen inches below the ordinary level of the reach, and upon it adjustable planks are arranged for regulating the discharge of water. This weir and the road bridge over it were completed early in 1879, and have been found to answer a good purpose. The works connected with the new

weir and bridge over it were commenced by the contractor with the knowledge that they were intended as a substitute for the enlargement of the old weir and bridge at that place.

Patrick Larkin, the contractor for Section No. 1, has been paid up to the 31st December, 1879, the sum of $520,500.

In September, 1878, a heavy rain storm of unusual duration raised many of the drainage streams near the western end of Lake Ontario to a height that caused serious damage to adjoining property. In the Niagara district it is said to have rained continuously for 70 hours, and on the 13th day of the month all the surface drainage outlets poured forth greater volumes of water than they were ever before known to have done at that season of the year.

The Twelve Mile Creek sent down rapidly an unusual quantity of water, and so large a volume from various sources was thrown into the canal above Thorold that the level was soon raised to a height that overflowed, and soon after, cut away a temporary dam between the old and new lines, rushing down the latter several feet in depth to Port Dalhousie.

It is, however, proper to state that little or no damage was done to the new works, so that the destruction of the dam may in reality be looked upon as a fortunate occurrence, for the reason that if it had stood there is every probability that serious damage would have been done to the weak banks of the old canal, between Thorold and Allanburg, and thus have led to the inundation of the country to the westward.

The great quantities of water from the various drainage courses, channels and streams soon raised the large pond between St. Catharines and Port Dalhousie to a height that threatened to overflow the bank formed across the lower end of the valley; notwithstanding that all the sluices in the lock gates, the spill-way of the weir and gates in it, as well as those in the adjoining mills, were all open.

This uncertain condition of matters continued for some time without any indication of the water subsiding; when the old weir was suddenly swept away, leaving only the side walls to mark the place where it had stood for the preceding 32 years.

At the same time one of the cribs of the new west docking, fully loaded with stone ballast, was carried bodily 150 feet north or downward into the new part

of the basin, and a considerable quantity of earth and debris of various kinds was washed into that part of the channel.

The water in the large pond was soon drawn down and the passage of all vessels through the canal stopped. Consequently a large fleet was in a short time collected both at Port Colborne and Port Dalhousie, the owners of which were most desirous to have their vessels continue their voyage as early as possible. After the water had subsided and some knowledge of the nature and extent of the disaster had been obtained, it was at once decided that an earth dam should be put in a short distance above the site of the old weir, and that the operations be pressed forward as expeditiously as could be done by a large force employed both day and night, until the water could be raised to such a height as would enable vessels to pass freely.

This plan was carried out, and navigation was resumed within one week of the time that the works were commenced. In effecting the speedy accomplishment of the object, credit is due to the contractor for Section No. 1 for assistance in many ways, and to the persevering efforts of the officers and men generally employed on the northern part of the canal. As soon as the necessary dam below the breach could be made up, the seat of the old weir was unwatered in order to ascertain the nature of the bottom, with a view to the erection of a new structure. It was then found that by a slight change in position a good foundation could be obtained, a larger structure built, and a better direction given to the discharge of the water.

All these being important requirements, it was decided that they should be taken advantage of in the site selected and design for the new weir, and with a view to the improvement of the line of the public road, that a separate bridge should be constructed over the entrance channel.—(See Appendix No. 2.)

These works are now under contract, about one half the cost of which is fairly chargeable to extraordinary repairs of the old canal, and the other half to the canal enlargement.

At the time of the destruction of the weir several vessels sustained slight injuries from the same cause (the rain flood) and for which the owners have claimed compensation.

In considering these matters, the question presents itself whether this extraordinary rainfall and flood do not come under the head of occurrences for which human foresight could not be expected to provide, and therefore the Department cannot be held responsible for their results.

It may further be stated that in placing and maintaining the canal in efficient working order, it seems as if the duties devolving upon the Department in charge of it had been fully discharged, consequently those using the canal may reasonably be expected to continue, from the time of entering to the time of leaving, to be responsible for the safety of their own property.

From the applications made for alleged damages to vessels it may be inferred that some of the owners of that class of property are, under the impression that vessels are, in a measure, insured by the Government the moment they enter a canal.

To guard against such impressions, it would be well to consider the advisability of giving public notice at the opening of navigation to the effect that the canals having been placed in good working order all those using them must assume the entire responsibility of the safety and security of their own property when passing through them.

SECTION No. 2.

The works on this section are completed, and the contractors, Messrs. Dennison, Belden & Co., have been settled with in full; the sum paid to them amounts in the aggregate to $511,408.40.

This part of the line and the works upon it may be briefly described as follows:—

It is situated chiefly in what is called May's Ravine, and is altogether about 2,700 feet in length, extending from a point a little south of the main road, between Port Dalhousie and St. Catharines to within about 1,000 feet of the entrance piers above the first lock.

Upon it there are two locks, two regulating weirs, abutments, etc., for a road bridge at the upper end of the third lock*, a bridge over the supply race, and one for the towing path below this lock, a dam between the lower side of the weir and the upper end of the second lock, and entrance piers at the lower end of the latter. (See Appendix No. 3.)

The lower lock (No. 2) on this section was not commenced until after authority was given to place all structures at a depth corresponding to a draft of 14 feet water, and as it connects with the upper inner basin, the level of which cannot be raised without flooding a large extent of low land and endangering existing works, it was considered proper to have the bottom sunk to meet the

*The numbering of the locks commences at Port Dalhousie and continues on upward.

contemplated future requirements. An arrangement to that effect was therfore made with the Contractors. At the requisite depth the materials were found to be of so varied and unequal a nature that, after a thorough examination of the place, instructions were given to have a bearing surface formed of concrete, for the floor timbers and base of the wall, as well as to have the cross vertical cut-offs at the recesses and at the lower end, together with the spaces between the timbers all made up with a like class of material.

The lock is situated in what was formerly a projecting high point of land on the south-westerly side of the ravine, and on the opposite or easterly side the regulating weir for the reach above is built.

In excavating for the foundation of the connecting wall between these structures, there was found the deep bed of an old water-course filled with various kinds of debris to a depth of from 10 to 12 feet, all of which had to be removed to a much greater width than if it had been of a harder nature. From the deepest part upward, the wall was built in stretches stepped off, at a rate corresponding to the inclination of the bottom, and carried up to the height of the adjoining works.

This wall from the lowest part of the foundation to the top is 37 feet high, it is built of a heavy class of stone laid in hydraulic cement mortar, and is well banked up on both sides; it is intended to serve as a means of cutting off the water with a less width of embankment than would otherwise have been required, and obviates the necessity of a wall below the weir.

In the vicinity of the lower entrance to the second lock, the bottom having been understood to be of moderately hard material, it was contemplated to form the approach or side piers of crib work with a stone superstructure.

This had in view not only the construction of permanent works at the entrance, but to ascertain in some measure the effect of masonry built on crib work sunk in deep water, and thereby assist in arriving at a conclusion relative to the comparative advantages of timber and stone, for the renewal of the superstructure of harbor piers.*

The bottom, however, turned out so very different from what was anticipated that the plan had to be abandoned. In fact it seemed at one time doubtful whether anything like a fair piece of work could be obtained, as the cribs settled down either inside or outside of the lines, or in some direction other than that

*This question has on several occasions occupied attention without any certain guide for its solution.

required. It was therefore found necessary to drive a few piles at some places, at others either to cut down or build up parts of the tops of the cribs at low water ; all of which combined was ultimately successful in enabling a timber superstructure to be put on in a substantial manner and to a moderately fair line.

It may here be stated that a continuous track-path through the upper basin, between the piers at the lower end of lock two and those at the upper end of the first lock, is proposed to be made by means of a floating roadway held in place by piles that are connected by cross and diagonal braces, and with a heavy railing on top, in a similar manner to that in use at several places between Port Dalhousie and St. Catharines.

The reach between the second and third locks is fully 1,300 feet long, and has a mean width of about 190 feet. It follows the line of the ravine, and although curving somewhat quickly its width will prevent any inconvenience to vessels passing in either direction, while its surface area and connection with the supply race above precludes the possibility of the height of the level being influenced to any appreciable extent by lockage.

The third lock adjoins the main road between Port Dalhousie and St. Catharines, the upper wings of which have been extended to serve as the abutments of a swing bridge to carry the road traffic; and on the same line, abutments and a centre pier for a fixed bridge over the raceway have been also built.

As stated in my report for 1877, on excavating the pit for the foundation of this lock, it was found that the bottom, at the required depth, consisted of quicksand so much charged with water that, at many places, the material yielded in every direction when a person attempted to walk on it. This was looked upon as so serious a matter that it led, at first, to the impression that the site of the lock would have to be changed. But, after considering the question, it was decided that, by confining the quicksand and forming an artificial crust over it of a suitable thickness, a foundation would be obtained which, with other precautionary measures, would be certain to answer all the purposes required.

In order to carry out this plan, a pit was sunk a short distance beyond the lower end of the lock and connected with channels cut on each side of the bottom, of a depth which drained the material that had to be taken out. On the water being kept well down at the lower end, the material for a stretch the full width of the pit at the upper end was removed to form a place for a stratum of concrete two feet in depth. This system was continued until a crust of concrete of the depth above mentioned was formed over the entire foundation, at the

proper level to receive the floor timbers. The trenches, cut for sheet piles at the mitre sill platforms and across the lower end of the foundation, were all filled with concrete.

The plan adopted, it may be stated, has answered a good purpose, as the lock has been completed for nearly two years without a crack being visible in the walls, or any indications of unequal settlement.

SECTION NO. 3.

On the first of August last the contractors for this section, Messrs. Denison Belden & Co., were settled with. The sum paid to them in the aggregate amounts to $339,247.02.

The works upon it embrace the formation of 2,500 feet in length of the canal ; the construction of two lift locks, two regulating weirs, abutments and piers for two bridges over side openings, and the cutting of a supply race. (See Appendix No. 4.)

The third and fourth locks are 800 feet apart, and the fourth and fifth locks 780 feet apart; they are each to have a lift of 14 feet. The bottoms of them are of pine timber, laid transversely, about six inches apart, generally of a length to reach from rear to rear of the side walls, and resting on sub sills placed near the front and rear of the respective walls; the spaces between the floor timbers are closely filled with puddled clay; the platforms under the entire space occupied by the gates, when in position, are formed of well jointed timbers of the full length to extend from one side of the foundation to the other, and fastened together by horizontal tie rods, anchored to timbers placed five feet below the bottom, and further secured by a range of vertical sheet piles on each side. The sills on which the gates are to bear when closed, are of white oak timbers of large dimensions, dressed, planed and tenonned into each other, partly let into the platform, and the whole strongly bound together by heavy wrought iron straps bolted to the timber underneath. Sheet piles are also put in at the lower end of the foundation, and the whole area of the bottom covered with close laid, well-jointed 3-inch plank, fastened to the cross timbers with white oak treenails. After the side walls are built, a second course of pine plank two inches thick, properly jointed, is laid over the whole area of the chamber and fastened with pressed spikes. This kind of foundation is laid, and the chamber floor formed, in all cases where the bottom is of moderately hard, compact clay.

From a point about 200 feet above the head of the fifth lock a supply race 60 feet in width at bottom is formed along the west side of the canal down

to May's Ravine, where the water from it will enter the reach above the second lock. In this race-way are built the weirs intended to regulate the water levels of the canal at the third, fourth and fifth locks. The water-stretches above these wiers are connected with the reaches or levels by side cuts above the respective locks.

In this way the water discharged, when emptying the lock above, will be carried off and the water supplied when filling the lock below, without, in either case, having any material influence on the height of the reach. The regulating weirs are of masonry laid on a foundation of timber placed 5 feet below the surface of the lower reach.

At the upper water line, the breast wall is 62 feet long between the side walls, leaving, exclusive of the centre pier, two spill-ways, each 29 feet in width, the tops of which are nine inches below the upper reach. In the breast wall there are in all cases six sluice-ways each 4 feet square. The gates for them will be on the upper side of the wall and be two feet in depth; they are to be opposite the bottom part of the opening to allow the water to break up before it passes beyond the lower face of the wall.

As stated in Appendix No. 13, "The natural drainage of the country between Lock No. 4 and the Queenston Road crossing at St Catharines, flows towards the north; this is intercepted by the canal and its works." On this stretch, long continued heavy rains and the melting of deep snow produce a great quantity of water, to dispose of which rendered the formation of a large ditch necessary along the west side of the land acquired for the new line of canal. This ditch discharges into a branch of May's Ravine at a place where the bank is steep. The outlet was therefore formed of masonry, the sides corresponding to the declivity of the ground, with cross walls at short distances apart, thus making the descent by a series of steps, to an arched culvert which carries the water under the public road into the level above the second lock.

Without entering into further details of this part of the line, it may be stated that Messrs. Denison, Belden & Co., Contractors for Sections Nos. 2 & 3, executed the works under their own direct management, and from the commencement until the completion of the whole, displayed not only a thorough business capacity, but in every respect showed a disposition to carry out in a straightforward, honorable manner all the conditions of the agreements they entered into with this Department.

Section No. 4.

The works embraced in the contract for this section are so nearly completed that the Contractors, Messrs. Blake Bros. & Campbell, have been settled with in full and paid the sum of $108,454.54.

They included the formation of the canal for a distance of about 3,250 feet; the excavation and grading required to form a new line for the Welland Railway for a distance of 5,944 feet; the construction of piers and abutments for two swing bridges, one for the railway and another for a public road, with small fixed bridges and culverts over the ditch for drainage, etc. (See Appendix No. 5.)

On this section, as previously stated, the canal line crosses that of the railway at a place where the track is very little higher than the surface of the ground, and where the level of the reach will be about five feet above it. The line of the railway was therefore changed, the grade upon it continued 1,500 feet further, but with less inclination than to the northward of the place where the change of line commences. This had to be done to enable the track to be raised about six feet higher than the canal level, and to get stretches of about 1,100 feet immediately on the north side of the bridge, and 2,200 feet on its south side, with little or no inclination.

This change will be made without any interruption to the railway traffic, and, in the arrangements throughout, safety and convenience have been duly considered.

The masonry and other stationary works for this bridge are arranged for the crossing to be made at an angle of about 52 degrees, and those for the public road crossing are at right angles to the line of the canal.

The quantity of excavation done on this section considerably exceeds that originally estimated, for the reason that a bed of sand overlying the clay was found to extend along a great part of the line, a large part of which had to be removed and wasted, and suitable materials for a water-tight bank brought from a distance to occupy its place.

The piers and abutments for both these bridges are unconnected with any other structures, and are similar to other detached bridge works elsewhere on the line, and of which a general description will be given further on, as well as of the superstructure and its equipment that have still to be placed under contract. The embankment for the new parts of the railway line are carried up to subgrade, the ballasting and tracklaying on which will be done by the company, if satisfactory arrangements to that effect can be made.

The works on this part of the line have been well executed, without anything more than ordinary supervision; it is, therefore, much to be regretted that a considerable part of the amount paid for it has passed into other hands than those who actually did the work, or furnished materials and provided means to carry it out.

Section No. 5.

In July last, the Contractor for this section, Alexander Manning, was settled with in full, the sum paid him in the aggregate amounts to $440,031.52. It extends over a distance of 3,200 feet, and includes the construction of two locks, two regulating weirs, abutments and piers at two openings between raceway and channel, etc. (See Appendix No. 4.)

The distance between the fifth or upper lock on section *three*, and the sixth or lower lock on section *five* is about six-sevenths of a mile; between the sixth and seventh lock the distance is 1,460 feet; both these locks have a lift of 14 feet. After the pits for them had been excavated, it was found that the bottom, in both cases, was of material of a soft, yielding nature when kept for a short time moist, but when exposed to the action of the sun, the surface hardened, seemed to contract when drying, leaving wide deep cracks in every direction through it to an extent that indicated there would be great risk in treating either of them as ordinary clay foundations. On considering the matter fully, it was decided that a foot depth of the material over the whole area of the bottom should be removed, and a like depth of hydraulic cement concrete be substituted for it, and laid to form a bearing surface for the floor and foundation timbers.

The sheet pile trenches at the mitre sill platforms and at the lower ends of the locks, also the spaces between foundation timbers, etc., were all filled with concrete.

The upper wings of the sixth lock, for fully a foot below the bottom of the upper reach, have been extended to form abutments and the rest pier for a swing bridge in line of Geneva Street of the City of St. Catharines, and a fixed bridge on the same line has been built over the raceway on the east side of the canal, and another over the ditch on the west side.

On this part of the line, the supply race and regulating weirs are on the east side of the canal, the openings of the former being near the upper end of the section, between the locks, and a short distance below the sixth lock, and the weirs are situated in the race between these places.

The quantity of excavation on this section has been increased over that originally estimated, by a like cause as stated in connection with Section No. 4, namely, coming across a bed of sand that had to be removed and wasted, and suitable material found as a substitute for it.

The whole of the works, although carried on under a sub-contract, have been executed in a creditable and satisfactory manner, without such annoyance as

frequently results from the necessity of conducting even minor operations under similar circumstances.

SECTION NO. 6.

In October last a full and final settlement was made with Patrick Shannon, the Contractor for this section, and the balance then due was paid, making, together with progress estimates, advances on drawback, etc., a total sum of $131,378.23, which the works on this part of the line have cost.

They consist of the formation of the canal for a distance of 7,000 feet; the construction of abutments and piers for a swing bridge to carry, over the canal, the Niagara Street traffic to and from St. Catharines; a small bridge over the drainage way on the west side of the canal, and the abutments and piers for two bridges over openings to and from the regulating race. (See Appendix No. 6.)

A considerable part of this section is in embankment, and the adjoining ground is so low that the surface level of the canal will be 10 feet over it. This necessitated great care to be taken in preparing the seats of the banks, as well as in the subsequent formation of them and the class of materials used for that purpose, especially as the remark made in relation to Sections Nos. 4 and 5 is equally applicable in this case, *i.e.*, a bed of sand was found to extend a considerable distance along the line, which had to be removed, and other materials excavated and brought a considerable distance, to occupy its place, as well as other precautionary measures adopted to render the banks impervious to water.

The abutments and piers for the bridge to be constructed on this section are of a like class as those elsewhere described for detached structures, and are placed so that the crossing will be at right angles to the canal.

The road and land in the vicinity being much lower than the bridge seat, the street on the west side was raised, and the bank extended a considerable distance westward with a view to diminishing the grade on the approach.

This, the Resident Officer, Mr. Monro, states, was done with the knowledge and consent, if not at the request, of the Street Inspector of the City of St. Catharines; nevertheless, the adjoining proprietor on the south side claims heavy damages for raising the street alongside of his property.

It is not known positively whether the City Corporation sustains the action of the Street Inspector or ignores it.

In case of the latter, and assuming that a steeper approach to the bridge would be preferable to allowing the street to remain at its present height, the

material can be removed and placed on canal property on the north side, at about one-third of the amount of the damages which the claimant alleges his property to have sustained.

The pipe from the city waterworks, which the Department granted permission, under certain conditions, to carry under the canal near this place, has been laid, and when doing this it is understood every precaution was adopted to guard against future accidents.

The works on this section, after a great deal of unnecessary trouble and annoyance, have been tolerably well executed; it is, however, to be regretted that satisfactory settlements were not, in all cases, made with those who actually did the work and furnished materials for it.

Section No. 7.

The Contractors for this section, Messrs. Higgins & Sullivan, were settled with on the 1st August last, and the balance on the final estimate was in a short time afterwards paid, making the aggregate cost of this part of the line amount to $388,672.30.

It extends from a line a little to the south of the road between St. Catharines and Queenston, a distance of 3,083 feet in a north-westerly direction. The contract for it embraces the construction of two lift locks—two regulating weirs—the abutments and piers at two openings between the supply race and the canal—abutments and piers for a swing bridge to carry the traffic of the public road above mentioned. (See Appendix No. 4.)

The distance between the seventh lock, Section 5, and eighth lock, Section 7, is about 7,405 feet, and between the eighth and ninth locks the distance is 740 feet; each of the latter two locks have a lift of 12 feet.

On excavating the pit for the foundation of the ninth or upper lock on this section, the bottom was found to be of a nature similar to that previously described for the sixth and seventh locks, except that when moist it seemed to get even softer, and when dry the cracks through it were larger and deeper. It was therefore decided that fifteen inches in depth of the material, below the regular line, should be removed for the whole area of the bottom, and a stratum of hydraulic cement concrete, laid on in layers, substituted for it, to form a bearing surface for the foundation timbers.

The spaces between these timbers, the sheet-pile trenches at the mitre sill platforms, and at the lower end of the lock are also all filled with concrete.

On reaching the depth originally contemplated for the foundation of the eighth or lower lock on this section, it was, from the nature of the material, considered advisable to remove a range 15 feet in width and 12 inches in depth along each side of the bottom, and to fill the same with concrete to form a bearing surface for both ends of the floor timbers and the side walls over them.

The lock masonry on this section was sublet by the contractors, and got into hands that required more than an ordinary degree of vigilance to be certain of the work being even moderately well executed. This, together with being rather unfortunately situated, in regard to a proper inspector at that place, led to a vast deal of trouble and annoyance until the true state of matters became better understood, when arrangements were at once made to suit the circumstances.

It is, however, proper to state that, although the contractors had, by their own acts, lost control of the works, one of their sureties took an active and creditable part, in seeing matters put right, as well as in exercising his influence at the right time to effect a full and final settlement of the business.

The supply race and regulating weirs on this part of the line are on the east side; the race connects with the canal a short distance above the ninth lock, where abutments and a pier for a bridge have been built. A short distance below this there is an outside basin of fully 4 acres area, the height of which is regulated by a weir that passes the surplus water into a lower basin of fully seven acres area.

From this lower basin, there is an opening into the canal that will supply water when filling the eighth lock, or carry off the water when emptying the ninth lock; the height of this basin is regulated by a weir in its north bank, and from which the water passes into a still lower basin or race, and connects with the canal by an opening formed near the south end of Section No. 6.

The abutments, piers and other works connected with the stationary parts of a swing bridge, to carry the traffic of the public highway from St. Catharines eastward, are ready for the superstructure and its equipment.

To enable this crossing to be made at right angles to the canal, the line had to be slightly changed, which leaves a triangular strip of land on the south side of the road, that will, in all probability, be applied for, and may reasonably be granted, as an addition to the cemetery property.

This crossing being an important one, it is contemplated that it, as well as others where there is much travel, will be constructed with a double track-way

and precautionary measures adopted, in all cases, for the safety of both night and day travellers.

Sections Nos. 8 and 9.

The representatives of Cairns, Morse, Hart & Co., Contractors for these two sections, were settled with in July last, and the balance then due on the final estimate was, a few days afterwards, paid to them, making the total cost of the works included in this contract amount to $564,673.77.

They extend over about one mile and a fifth of the line, embracing the formation of the channel for that distance ; the construction of three regulating weirs, the abutments and piers for four bridges over openings between the side basins or raceway and the canal ; the construction of the stationary parts of a swing bridge for a public road over the canal, and a culvert to pass the waters of the Ten Mile Creek through under the line. (See Appendix No. 7.)

The reach, between the ninth lock on section *seven* and the tenth lock, is about 2,290 feet long ; that between the tenth and eleventh locks is 3,515 feet in length, and the distance between the eleventh and twelfth locks is 714 feet. All the three locks on this section have each a lift of 12 feet, and the foundation for each of them was prepared, laid and secured as described for the fourth and fifth locks.

On these sections the supply race, regulating weirs and a series of basins commence to be formed on the westerly and northern sides of the line up to about the 22nd lock.

These basins or ponds are, in some cases, of considerable extent, and are intended to be, invariably, of the same height as the reaches with which they connect by means of the openings made through the banks. These openings, as has been stated in other cases, are intended to admit a supply of water when filling the lock below them, and to carry off the water when emptying the lock above them.

The basins are to be maintained at their proper height by a constant overflow from the summit level, regulated by large weirs built outside the line of the canal.

Thus the various comparatively short reaches along the rapid ascent near the foot of the escarpment will be in a great measure free from currents of any kind and subject to little or no variation of level, as the water supply, except what is required for lockage, will for the most part pass wholly on the westerly and north-westerly sides of the channel, which is considered to be an important and distinctive feature of this part of the line.

The culvert to carry the water of the Ten Mile Creek through under the canal was amongst the first works executed on these sections; it has now been in use for several years, and fully answers the purpose contemplated.

The abutments, piers and stationary works for the roadway bridge have been constructed; abutments and piers for bridges over the regulating openings have been built, and all the works embraced in the contract executed and completed.

The whole of the lock masonry on these sections was done under a sub-contract; nevertheless, it was in the hands of a person who conducted the operations in a manner, that with close supervision, a moderately good class of work has been secured.

The original contractors (once quite numerous) for these sections, had all in some way ceased to be connected with the undertaking, and, therefore, had nothing whatever to do with the closing up of the business; it is, however, proper to state that no contractors could have acted in a more straightforward manner than Messrs. Hunter and Murray, the gentlemen with whom the final arrangements were made.

Section No. 10.

The contractors for this section, John Ginty & Co., represented by Alexander Manning, were settled with in July last, and the balance then due was soon afterwards paid, which, together with advances on progress estimates, amount in the aggregate to the sum of $385,621.97, as the cost of the works on this part of the line.

It is about 2,107 feet long, and embraces the construction of two locks, two regulating weirs, abutments and piers for two bridges over regulating openings, extending the lower wings of the thirteenth lock so as to form abutments and rest piers, etc., for a swing bridge, forming approaches to the bridge seat, building two small bridges to continue the line of road on the west side of the canal, and forming basins. (See Appendix No. 7.)

The reach between the 12th lock (Section 9) and the 13th lock is about 750 feet long, and the 13th and 14th locks are fully 680 feet apart; each of the two latter has a lift of 12 feet.

On the pit for the foundation of the 14th or upper lock on this section having been excavated to the full depth contemplated, the bottom material was found to be of a similar nature to that already described as being in the bottoms

of Locks Nos. 6, 7 and 9; it was, therefore, decided that for the whole area of the foundation the material should be removed for a depth of fifteen inches, and a stratum of concrete of a like depth be substituted for it, to form a bearing surface for the floor timbers and side walls.

Concrete was also used in the sheet pile trenches, at the mitre sill platforms and at the lower end of the lock, as well as between the timbers in the chamber and at other places where it could be used advantageously.

The spaces between the foundation timbers and all the sheet pile trenches, in the *thirteenth* lock, were also filled with concrete.

All the works above enumerated as embraced in this contract, and such others as are common to other sections or parts of the line, and to which attention will be subsequently drawn, are fully and satisfactorily completed.

The roadway leading to and from the bridge over the lower lock has been made of the full height and width, and two stationary bridges built for it, one over an opening between two ponds, and another over a small tributary of the Ten Mile Creek.

It may here be stated that Alexander Manning, the managing partner of the firm, personally conducted the business connected with the greater part of the work on this section.

Section No. 11.

In July last the representatives of the contractor for this section, Paul Ross, were settled with, and the balance due on the final estimate was, a few weeks afterwards, paid, all of which shew that the works on this part of the line have cost the sum of $376,645.80.

It is about 2,250 feet in length, the contract for which provides for the construction of two lift locks, a regulating weir, building abutments and piers for two or more bridges over regulating openings, and the construction of a culvert of sufficient capacity to pass the traffic of a public road under the canal. (See Appendix No. 7.)

The reach between the 14th lock (Section 10) and the 15th lock is about 700 feet long, the 15th and 16th locks are about 625 feet apart; each of the two latter has a lift of 14 feet.

The foundations for them were prepared, laid and secured as described for the 4th and 5th locks.

The road culvert has been in use for nearly two years; it is fourteen feet wide in the clear, and fourteen feet high from the surface of the road to the underside of the arch, which is 291 feet long.

The total length from the outer end of the wings on one side to a like point on the other side is 331 feet. It is situated on a part of the Thorold and St. Davids Road, where the ground is comparatively low and the banks of the canal high, which enabled the approaches to it, on both sides, to be made with only a slight inclination, and the low ground on the east side afforded good drainage for the lowest part of it.

This culvert has no doubt cost more than the amount that would have been required to construct a swing bridge over the canal, but its future maintenance will be small compared with the keeping up and renewal of a bridge. The safety of the public is in every way better provided for by a culvert, and there can be no delay either to the navigation or to the traffic of the road.

To the westward of the culvert, about 600 feet, the road crosses the regulating raceway, where stone abutments and piers have been built and a substantial bridge crossing constructed.

All the works called for by the contract have been carried out, and although there was from time to time considerable difficulty in getting them up to the standard required by the specification, still there is reason to believe that subletting in this case has been attended with better results than if an attempt had been made to conduct the undertaking under the management of the original contractors.

Section No. 12.

The works on this section are well advanced towards completion; they comprise the formation of about 2,115 feet of the new canal and certain basins on its north-western side, the construction of two locks, two regulating weirs, the abutments and piers for two bridges over regulating openings. The section also includes all the works connected with the formation of about 7,500 feet of a new line for the diversion of the Great Western Railway, embracing the construction of a tunnel, the thorough drainage of the cut, sodding of the slopes, building culverts, a road bridge, etc. (See Appendix No. 8.)

The distance between the 16th lock (Section 11) and the 17th lock is about 840 feet; the 17th and 18th locks are 780 feet apart, and each of the two latter has a lift of 14 feet.

The material forming the bottom of the 17th lock being of an unusually soft nature, it was decided to remove two feet in depth of it under the side walls and one foot at all other places, and to make up the whole with concrete to the proper height to form a fair bearing for the foundation timbers. The spaces between these, as well as the sheet pile trenches, were also filled with concrete.

The foundation for the 18th lock was prepared, laid and secured as described for the 4th and 5th locks. It is considered proper to remark here that in all cases where short reaches are on a curve, the convex side is more or less flattened, according to the degree of curvature.

Diversion of the Great Western Railway Line.

As before intimated, the works embraced in the contract for this section are nearly completed, at least they are as far advanced as they can be until the line of the Great Western Railway is changed, nevertheless the line of the railway cannot be altered until certain arrangements are made and works done that are not included in the contract for Section No. 12.

These works consist in lowering and grading as much of the present railway track as may be necessary to the eastward of Section 12, the ballasting and laying the track upon it and also on the new part of the line, all of which works are covered by the agreement made between the railway company and this Department.

It may further be stated that the mode of carrying them out was previously, and at the time of the execution of this agreement, distinctly understood by both parties.

With a view to an explanation of this matter, the statements made in my report of 1877, relating to it, are repeated, and such further details given as seem to be called for by the circumstances.

This course is considered indispensable from the fact that the carrying out of the agreements, written or verbal, devolves upon others than those who, in the first instance, were parties to the making of them.

On this section the line of the new canal crosses the track of the Great Western Railway, at a place where there is a grade of about 38 feet to the mile for a long distance on both sides of the intersection.

It was therefore urged by the representatives of the company that, under these circumstances, they could not consistently consent to have the track carried

over the canal by means of a swing or draw bridge, not only from the delay to which their trains would be subject, but from the danger that must inevitably result to the travelling public.

They, at the same time, submitted a sketch plan, showing that a tunnel might be constructed under the canal for the passage of the railway traffic, and stated they would be fully satisfied if it was carried out. After considerable discussion on the subject, it was arranged that the line of the railway should be changed as nearly as possible to that indicated on the plan, that this fact, together with a number of conditions discussed and agreed to, should be embodied in a written memorandum and signed by the proper representative of the Great Western Railway Company, and by the Minister of Public Works on the part of the Government.

There was, however, considerable delay in getting this document executed, which, it is believed, could not well be obviated in the state of the Company's affairs at that time. It is dated the 22nd day of April, 1875, and provides, amongst other matters, that the "Department of Public Works shall construct a tunnel "under the canal at a point above Lock No. 18, and do all the work required for "forming a connecting link of railway through and between it and the main line; this connection to be in the aggregate about 7,500 feet in length."

In no case is the curvature to be "less than 1,443 feet radius, and the "gradient nowhere result in more than 42 feet per mile, either in the connecting "link or in the adjoining existing line, the cuttings to be at least 24 feet wide "and embankments 18 feet wide on top, and the workmanship throughout to "be executed in the best manner."

"The Great Western Railway Company agree to pay for the necessary "right-of-way for the new line, other than where it passes through Government "property. In the latter case the Company to receive a title from the Depart-"ment of Public Works to such a quantity of Dominion land as may be "reasonably required for the cuttings, embankment, drainage, etc., of the new "line."

"The Railway Company to convey to the Department of Public Works "such of their lands, connected with the present track, as lie between the east "and west boundaries of the property recently purchased by Government for "canal enlargement."

"In consideration of the Government constructing the line of railway, "tunnel, etc., instead of building a draw-bridge, as originally contemplated, the

"Company agree to waive all claims for prospective losses arising from increased "length of line, curvature, grade or any cause whatever connected with the "operation or maintenance of the line, when constructed in the position above "indicated."

It was then, as well as now, known that to carry out this arrangement involved the necessity of lowering about four-fifths of a mile of the main line of the railway, beyond the eastern end of the point of diversion.

The representatives of the Company urged that the execution of this part of the work could not reasonably be entrusted to an ordinary contractor, and that they, therefore, must insist that the Railway Company have the entire control of it. Moreover, that when doing this work the Company could advantageously ballast the new part of the line and lay the track upon it, in the manner considered best for the interests of the railway. This proposition was then, as now, looked upon as fair and reasonable, provided the Company would undertake to do the work and provide the necessary materials at moderate rates.

To get at a proper basis of settlement of these matters, it was verbally agreed that the Company should authorize one of its officers, or some other person, to meet an officer or person named and authorized by the Government, to look into this part of the business with a view to a satisfactory arrangement, when the time for that purpose arrived. If this view of the subject is still favorably entertained by both the Government and the Railway Company, steps should be taken to carry it out by each naming and authorizing a person to act in the matter.

The tunnel is 665 feet long, which, together with the wings, makes a total length of 713 feet; it is 16 feet wide in the clear, and 18 feet high in the centre over the rail level. The arch is a semi-circle, and the whole is on a curve of 1,443 feet radius.

Through the tunnel the track will be nearly level; to the westward of it the grade is about 21 feet to the mile, and to the eastward it at no place exceeds the inclination agreed upon, 42 feet to the mile. To secure this grade east of the new part, four-fifths of a mile of the main line will have to be lowered.

The side slopes in the cuttings are one and a half horizontal to one vertical, they are well sodded and for the most part thoroughly drained. The toe of the slopes on both sides of the road-bed are supported by low continuous walls, connected with water-courses of dimensions suited to their position and formed of pitched stone laid in hydraulic cement mortar. The road-bed is made up to sub-grade; the large culvert at the west end of the new line lengthened out; an over bridge

built for a common road crossing; water-courses are formed on both sides of the tunnel of concrete, pitched stone, etc.; culverts built where required, and everything done in the most substantial manner, fully equal to the requirements of the most liberal interpretation of the agreement.

Messrs. Lobb, Dawson & Murray, the contractors for Section No. 12, have been paid, up to the 31st December, 1879, the sum of $529,800.

Section No. 13.

The contractors for this section, Messrs. Ginty and Dickey, represented by Alexander Manning, were settled with in July last, and the balance then due was paid in January, 1880, which, together with advances on progress estimates, amount in the aggregate to the sum of $352,099.31, as the cost of the works on this part of the line.

It embraces the formation of 2,000 feet in length of the new canal, the construction of two locks, two regulating weirs, the abutments and piers for two bridges over regulating openings, and the formation of basins on the north side of the canal. (See Appendix No. 4.)

The distance between the 18th lock (Section 12) and the 19th lock is about 650 feet, and the reach between the 19th and 20th is about 765 feet long; both of the latter locks have 14 feet lift.

The foundations for them were prepared, laid and secured as described for the 4th and 5th locks.

The works on this section were sub-let to persons who displayed considerable energy in pushing forward the operations, but required to be frequently reminded about the proper class of work.

Section No. 14.

The whole of the works covered by the contract for this section are completed, and the detailed final estimate of them is now in course of preparation.

They consist chiefly in the formation of about 2,025 feet of the channel, the construction of two locks, two regulating weirs, building abutments and piers for three bridges over regulating openings, forming basins on the north side of the line, etc. (See Appendix No. 4.)

The distance between the 20th lock (Section 13) and the 21st lock is about 690 feet, and the reach between the 21st and 22nd locks is 665 feet long; both of the latter locks have 14 feet lift.

The foundation for the 21st lock was prepared, laid and secured as described for those on Section No. 3.

The masonry of this lock was finished in the latter end of May, 1876, being the first lock completed on the new line, a result that gratified the contractor to a degree that can only be appreciated by a person who, like him, was so thoroughly devoted to his business as to be desirous of excelling in the production of both the quantity and quality of the work with which he was then or had been previously connected, and, it may be stated, seldom failed in honorably accomplishing the contemplated object.

On excavating the pit for the foundation of the 22nd lock, part of the bottom was found to be of rock and part of clay. The rock being a soft shale ranging obliquely across the pit, the upper layers of it, for a depth of six inches, were taken off, and the clay, for a depth of 15 inches, was also removed. The whole was afterwards made up with concrete to a height suited to form a fair bearing surface for the foundation timbers, the spaces between which, as well as the sheet pile trenches and spaces between side walls, were also made up with concrete.

Opposite and below the 21st lock there is a pond or basin on both sides of the line, each of which connects with the adjacent reach in the usual manner. The pond on the south-east side receives part of the regular supply water, which passes over certain cross-walls built in a raceway formed in rear of the 22nd lock.

The payments made for work done on this section up to the 31st December, 1879, amount in the aggregate to the sum of $340,200.

Section No. 15.

This section is situated in a ravine to the east of the Town of Thorold, the proper treatment of which has required all the care and attention that the resident officer, Mr. Monro, could bestow upon this, one of the most important and specially interesting parts of the line connected with the scheme of canal enlargement.

The contract for it embraces the cutting and formation of the channel for a distance of 2,050 feet, cutting a supply race on the east side of the line, forming

a new course for the Ten Mile Creek, and all the excavation necessary to admit of moving the track of the Welland Railway about 120 feet to the westward. It also includes the construction of two lift locks, and the extension of the wings of the upper one to form abutments and rest piers for a swing bridge, the construction of piers and abutments for a stationary bridge over the raceway on the east side of the canal, the abutments and piers for a bridge over the Welland Railway, building retaining and division walls, etc. (See Appendix No. 9.)

As stated in a previous report, the principal part of the ravine above mentioned is owned by the Welland Railway Company, and the central portion of it, at the time of commencing the works, was occupied by their track.

This line having been considered for many reasons the best for the canal, provision was made in the contract to cut a sufficient width off the west bank to admit of moving the railway track to a position where it would be outside the range of the canal works, and at the same time be beneficial, rather than otherwise, to the line itself.

This work was necessarily the first undertaken, and, from its extent and nature, occupied considerable time; but the change was ultimately accomplished, even to the satisfaction of the railway authorities, with whom, it may be stated, arrangements were made to find both the ballast and the iron, and do all the work necessary over sub-grade.

Before changing the railway line, a channel of sufficient capacity had to be formed to carry off the waters of the Ten Mile Creek, which rise to a considerable height, and come down rapidly during snow floods and rain storms of long continuance.

This channel is between the railway and canal works; it is 10 feet in width and about 2,300 feet in length; both sides of it are of a good class of dry, rough, random-coursed masonry, and where the bottom does not consist of rock in position, it is made of closely-laid pitched stone, having throughout an inclination of 83 feet to the mile, or about the same grade as that of the railway.

The distance between the 22nd lock (Section 14) and the 23rd lock is about 740 feet; in this reach the line curves considerably to the south, but the convex side is flattened, so that about the middle the bottom width is fully 150 feet. In this part of the excavation a stratum of cement stone was found, which, together with a moderately good class of building stone, obtained there and elsewhere, enabled the contractor and his representatives, with good management, to do the

work on the section profitably and well, even at the very low rates at which it had been undertaken.

From the unsound and fissured state of the rock on the north-west side of the bottom of this reach, part of it had to be covered with a bed of concrete to guard against leakage.

The distance between the 23rd and 24th locks is about 840 feet; the lift of the former is 14 feet, and the latter will have a lift of 16 feet until what is called the mountain range of locks are raised sufficiently to adapt them to a fourteen feet line of navigation.

In the pit excavated for the 23rd lock, the dip and irregularities were such that the southern end was 22 inches lower than at a point 260 feet further north, where the rock was at the right height, consequently an average of 11 inches in depth of concrete for the entire width of the pit, and for the distance above mentioned, was necessary to form a proper bearing for the foundation timbers. Concrete was also used between the floor timbers in the transverse trenches, and at places adjoining the rock in rear of the walls.

The surface of the rock in the reach above this lock was found to be, at many places, so much broken and fissured that it was decided to remove the upper stratum and otherwise lower the bottom at least eighteen inches, and afterwards cover the whole area that had been sunk, with a layer of prepared puddle, in order to prevent the water escaping.

At the place excavated for the seat of the 24th lock, the rock was found to be broken and so uneven that its surface varied from 3 to 36 inches below the proper level for the cross timbers. The whole area was, therefore, brought to a level surface with concrete, which required an average depth of fully 18 inches; concrete was also used between the timbers and to fill the trenches across the foundation.

The walls of this lock have been carried up two feet higher than originally intended, with a view to adapting the reach above to a 14 feet navigation without the necessity of future interference with the water level. In order to have the principal road crossing over the canal as near the centre of the Town of Thorold as possible, the upper wing walls of this lock have been extended to form the abutments and rest piers for a swing bridge, and, on the west side, abutments and piers have been built for a high-level bridge over the Welland Railway; and, in a line with these, arrangements have been made for placing a bridge over the race on the east side of the channel. This supply-race leaves the canal a short distance

above the 24th lock; it is about 58 feet in width, parallel to the channel, but separated from it by a heavy wall of random-coursed masonry, through which there are numerous openings for the entrance or exit of water when filling or emptying the respective locks. The proper levels in the different parts of this race will be regulated by the weirs constructed across it in the vicinity of the locks. The embankments on the east side of the locks are protected by a facing of pitched stone, and the east slope of the raceway at the upper end is supported by a built retaining wall, and at other places by a rip-rap wall faced with hand-laid pitched stone.

It may be stated that, although the supply race on this part of the line is on the east side of the canal, and the weir at the 22nd lock is on the north-west side, there will not be an oblique current in that reach due to the full supply, as part of it will pass on the south-east side of the lock through the subsidiary raceway before mentioned.

The west side of the reaches below the 23rd and 24th locks is formed by means of retaining walls of heavy, rough, random-coursed masonry, laid in cement mortar, varying in height from 18 to 32 feet, outside of which are heavy, well-made earth embankments. The slopes of the banks on both sides of the ravine have been thoroughly drained, and they, as well as other bank slopes, have been carefully sodded. It may further be stated, that all the works covered by the contract have been carried out in a satisfactory manner, and that a detailed final estimate for them is now in course of preparation.

The payments made for work done on this section up to the 31st December, 1879, amount in the aggregate to the sum of $494,700.

Section No. 16.

This section forms a continuation of the new line to within a short distance of where it intersects the Welland Railway in what is known as Marlatt's Pond. It was first awarded to, and a contract for the execution of the work upon it made, with John Elliott & Co., who subsequently transferred the whole of their interest in it to the late John Brown, whose representatives have carried the undertaking to completion.

The contract includes all the clay and rock excavation necessary to form a channel-way of the dimensions required for a distance of 3,500 feet; the construction of a syphon culvert, with two arched openings, to pass the water of the Ten Mile Creek under the canal; building slope and retaining walls, etc. (See Appendix No. 10.)

The new line passes through the same ridge as the present canal does above the Town of Thorold; but the rock cutting upon it is of much greater extent in every way than upon what is called the "Little Deep Cut."

The syphon culvert in connection with the conduit for the creek has been in use for several years, and fully answers the purpose contemplated in its construction.

The side walls form a continuation of those on Section No. 15 until they strike the rock at a like height; beyond this, where the rock is low, walls are built of the necessary dimensions until the surface of the rock begins to descend rapidly towards the south, where side walls are discontinued, and the line gradually winds round to the earth slope of two horizontal to one vertical.

All the works covered by the contract have been completed, and the payments made up to the 31st December, 1879, amount to the sum of $261,800.

The completion of the works on Sections Nos. 14, 15, 16, 21 and 22, since the death of John Brown, the contractor, in June, 1876, have been prudently conducted under the general management of R. B. McPherson, a trustworthy person, judiciously selected and appointed for that purpose by the Court of Chancery.

As before stated, arrangements have been made for the travel to and from the east side of the new canal, in the vicinity of Thorold, to pass over a bridge constructed at the head of Lock No. 24, as the place best suited, in many ways, for that purpose.

To accomplish this in a way likely to meet all requirements, the main travelled road, as well as other inferior lines occasionally used east of Thorold, have been diverted towards this point, forming, as a whole, what certainly appears to be the best arrangement that could, under the circumstances, be made for the accommodation of the travelling public and the benefit of the town.

It is, however, proper to state that the County Council of Welland, in June, 1878, addressed a memorial to the Department representing that another bridge over the new canal at Thorold would be necessary; and in July of the same year the Corporation of the Town of Thorold sent a memorial to the same effect.

In both these documents attention is principally drawn to certain east and west roads in the vicinity of Thorold that have been cut off by the new canal, viz.:—

1st, a concession line called Regent Street; 2nd, the Stone Road from Thorold to Clifton; 3rd, Hoover's Road.

The "1st" it may be said, runs obliquely along the steep side of the mountain; part of it latterly has been cut into deeply for a quarry; it was barely passable at any time for waggons, and never was a means of communication of any practical value.

Hoover's Road and the Stone Road are parallel to each other, and about 1,420 feet apart. The bridge at the head of Lock No. 24 is a few feet south of the west end of Hoover's Road and about 1,420 feet north of the Stone Road.

To meet the requirements of the locality, and at the same time guard against incommoding unnecessarily a great public undertaking, a new line for the Stone Road has been formed from a point 660 feet east of the canal, in a northern direction along the boundary of the Government property to near the line of Hoover's Road, where it takes a westerly course to the crossing at Lock No. 24.

The new part of the road is an independent line formed on canal property, it is macadamized, well drained, has easy grades, and, as a whole, is a good piece of road.

Thus the Stone Road and Hoover's Road meet at the bridge, from which a road has also been made along the east side of the canal and continued in a direction to intersect the north and south road near the Thorold Cemetery.

This part of the new road is formed on land purchased specially for that purpose.

In this way it seems as if ample provision has been made for all the lines of travel referred to by the memorialists; whilst the mere assertion that one bridge is not sufficient is really no more convincing than the surmise that a bridge at the end of a lock would delay travel more than a separate structure, especially when it is borne in mind that there are swing bridges over some of the Dominion canals, both at the ends of locks and elsewhere, that accommodate double the extent of traffic that is at all likely to be required between Thorold and the country to the eastward of the new canal for many years to come.

The cost of the under-works and superstructure of a swing bridge, in keeping with those on other parts of the canal, would amount to about $40,000, besides its working expenses and maintenance, an outlay that might reasonably be delayed until there is at least a probability of some benefit resulting from it.

On a careful examination of the country between Thorold and Allanburg, it was found that by continuing the summit level north to near Marlatt's Pond, instead of descending by a lock at Allanburg, a very considerable outlay for deepening would be avoided, and, at the same time, a fair line, although not a straight one, could be obtained at even less expense than the enlargement, deepening and improvement of the old canal.

The formation of the new line was the more desirable from the fact of the crookedness of the old one having been long known to lead, in certain winds, to the detention of the class of the vessels in use, consequently, unless great improvements were made, the difficulties would be greater when the longer vessels, contemplated in the scheme of enlargement, are introduced. Besides, the long high banks of the old canal could not be interfered with in summer, while moving and making such banks in winter would not only be difficult but very uncertain.

These and other reasons, stated in my report of 1877, led to the decision that an entirely new and separate line for this part of the route should be formed, the position of which may be briefly described as follows:—

From the south end of Section No. 16 it gradually winds round to a south-westerly course and crosses the line of the Welland Railway in an oblique direction, continuing on through Marlatts's Pond towards the south-east end of the macadamized road bridge, a short distance to the south of which the lift lock and other structures are placed.

It then follows a south-westerly course to the road leading to what is called Marlatt's Bridge, then curves slightly towards the south, until near the west road between Thorold and Allanburg, to which it runs parallel for about three-fourths of a mile; then curves gently to the south-east, intersecting the Holland Road near the north end of the Village of Allanburg, when it follows a straight course along the west side of that place on the line of the old, or original, canal, to the north end of the "Deep Cut."

The works on this part of the line are, with a view to continuous notation, divided into four sections, and in September, 1877, they were let in two separate contracts.

Sections Nos. 17 and 18.

These two sections have, collectively, a length of about 7,850 feet, and are comprised in one contract, which covers the formation of the canal for that

distance. It also includes the construction of a lift lock, building abutments and piers for two road bridges, the piers and abutments for a bridge to carry the line of the Welland Railway, the works connected with a set of guard gates, two arched culverts, a regulating weir and supply race, bridge abutments and piers to and from supply race, road bridge over raceway, etc. (See Appendix No. 11.)

The distance between the 24th lock (Section 15) and the 25th lock (Section 17) is fully one mile; the latter forms the northern terminus of the summit level, which is intended to be generally about the same height as Lake Erie.

On excavating the pit for the seat of this lock, the bottom was found to be so soft that it was considered necessary to remove the material twelve inches lower than originally intended, and substitute for it a stratum of concrete to form a bearing surface for the foundation timbers. The sheet pile trenches and spaces between the timbers were also filled with concrete.

At ordinary stages of the water the lift of the lock will be a little over three feet; at extreme low water in the lake its lift will be very little over two feet.

The side walls are, however, made of a height suited to the Grand River level, which is 8 feet higher than ordinary low water of Lake Erie; this is considered necessary in case it should, from any cause, be found desirable to use for a time the higher level.

The lower wings of it have been extended to form abutments and piers for a swing bridge to carry the traffic of the Thorold and Allanburg macadamized road, the line of which will be changed to correspond with the position of the canal works. It may be stated here that, at both ends of this lock and at the lower ends of all the other locks, fender cribs have been built and carried up to within a foot of the surface of the reach in which they are placed. On the front side they are generally 37 feet long, and the timbers are in part let in obliquely into checks cut in the masonry. In each case the face is carried up to the batter of the side walls, and at the outer end they have a batter of about one-half to one; thus the face has a winding batter intended to guard against injury to vessels when entering the lock.

The cribs are secured by vertical binders, cross ties and bolts, and well filled with stone ballast. On the top of them and in continuation of the wings, rubble walls laid in cement mortar are carried up on a line with the wing walls and winding round, so that, within a distance of 100 feet, the face has an inclination of two horizontal to one vertical, or the same as that of the banks of the canal.

At the upper ends of the locks a connection between the wings and bank on each side is made by means of a wall commencing nearly vertical and winding round in like manner as above stated for the lower end, within a distance of 100 feet.

About 750 feet above the lift lock, the side walls have been built and other arrangements made for a pair of guard gates. On the west side of these structures a supply race has been formed, a regulating weir built and arrangements made for a fixed bridge over it, in continuation of the road crossing.

As previously stated, the new line of canal is formed through Marlatt's Pond; this is done by means of continuous solid embankments carried across it to a height of fully 8 feet over the water surface.

To prevent the drainage of that part of the country east of the canal from being obstructed, and to maintain the water on both sides of the pond at nearly the same height, a syphon culvert of masonry has been constructed through, under the new line, of the capacity, arranged and secured in the manner required by its position.

It has been for a considerable time in use and has undergone as severe a test, without the slightest injury, as it can be under any circumstances subjected to in future.

To enable a bridge for the Welland Railway crossing of the new canal to be built at the proper place, it was found necessary to divert the line for a time about 100 feet to the westward on embankments at both approaches, and strong trestle work formed across the pond, over which all the traffic of the road passes.

A rock foundation for the piers was found at a few feet below the bottom of the reach; from this the masonry was carried up, which, together with the other under works for the bridge, are nearly completed.

The abutments, piers and under works for the bridge at Marlatt's Road are nearly finished. The culvert at Beaver Dams Creek has been in use for over a year, and the works generally are well advanced, and have been invariably carried out agreeably to the terms of the contract. The payments made on them up to the 31st December, 1879, amount to $446,000.

These were awarded to R. J. Campbell, and a contract entered into with him for their completion. He shortly afterwards sub-let them, and ultimately assigned the whole of his interests in the contract to his sureties.

Sections Nos. 19 and 20.

These sections include the formation of fully one mile and a quarter of the new line between Thorold and Allanburg; the enlargement, for fully a quarter of a mile, of the original canal, situated immediately west of the latter place; thence the enlargement of the present canal for a distance of about one-fifth of a mile to the south end of the "Deep Cut."

They embrace the works connected with forming two small arched culverts under the new line; the construction of abutments and piers for a swing bridge to serve as a road crossing at Allanburg; building a retaining wall on the west side of the new line from the head of the guard gates northward; the extension of the north wing walls of the guard gates to form the abutments for a swing bridge across the present canal; the construction of a weir in the bank on the west side, and channel from it for the supply of present canal, etc. (See Appendix No. 12.)

The construction of the supply weir and other parts of the works, on these sections, as are directly connected with the summit level, was attended with a good deal of expense and difficulty, as they had to be executed in winter and early spring, when the water in the canal adjoining them stood at a height corresponding to the level of Lake Erie.

The weather, however, proved to be exceptionally mild, and the person to whom the contractors had sub-let the masonry being both skilled and energetic, the whole of them were completed in a creditable manner in good time for the opening of navigation the following spring.

It may further be said that all the works above enumerated are either completed or well advanced towards it, and that the greater part of the excavation has been done, and what remains can be readily finished during the present year.

The payments made to the contractors, Messrs. Haney, Haney & Parry, up to the 31st December, 1879, amount in the aggregate to $299,600.

These sections terminate the new and northern part of the canal upon which, as before stated, all the lift locks, weirs, etc., are situated between Lake Ontario and the intended summit level; embracing, in the aggregate, an extent of excavation, masonry and other works that have seldom been executed in any other undertaking within a like distance of 11½ miles. The quantities of the principal items, as given by Mr. Monro in Appendix No. 13, are as follows:—

Earth excavation	5,375,000	cubic yards.
Rock do	150,000	do
Masonry of all kinds	369,000	do
Timber	1,475,000	cubic feet.
Plank	4,000,000	feet B M.
Puddle	150,000	cubic yards.
Hydraulic cement concrete	37,000	do

These various works necessarily required great care and attention on the part of the resident officer and his assistants; it is, however, proper to state that, from their respective positions, they were easily accessible at all times, and are, with the exception of the 1st and 2nd locks, advantageously situated in respect to drainage and otherwise.

SECTIONS NOS. 21 and 22.

At Allanburg the works connected with the enlargement of the canal previously formed and in use, commence, and are continued throughout the southern division of the line to Port Colborne.

The two sections above mentioned form the first part of this class of work and are comprised in one contract, which provides for taking a continuous strip of from 45 to 50 feet in width off the face of the west bank of the "Deep Cut" down to two feet over ordinary water level, making the slope 2½ horizontal to 1 vertical, and placing the material in rear of the existing banks without, in any way, increasing their height.

It also embraces the lowering of the bottom three feet below the level of the mitre sill of Port Colborne lock for a distance of 10,900 feet, with side slopes of 2 horizontal to 1 vertical, the contractor either to take the material to the Niagara River below the Village of Chippawa, or find approved spoil ground somewhere else at his own cost. (See Appendix No. 15.)

In the course of executing the works, the contractors found it necessary, in order to facilitate the operations, to adopt both these courses, *i.e.*, to take part of the material to the Niagara River and dump it there, and to purchase deposit ground, where the material had to be twice handled in order to get rid of it.

All the works covered by the contract have been completed and taken off the hands of the administrators to the estate of the late John Brown.

... the 31st December, 1879, amount in the

... considered proper to state that in 1874, before the ... a contract was made for lightening the east ... consisted in the removal of a strip of about 40 ... increasing the slope to 2½ horizontal to 1 vertical.

... this part of the works it was found that it would be ... a large part of the excavated material to the north or ... and deposit it on canal property, than to purchase valuable ... convenient for that purpose, or to interfere with the line of ...

... covered by this contract were completed in 1875, and a final ... with Robert Mitchell & Co., the contractors, which in the ... amounted to $105,710.

... the two contracts above referred to 1,757,552 cubic yards of earth, ... have been removed from this stretch (about 2 miles in length) of ...

It may again be stated that the slides and settlements that have, from time ... taken place in the banks of the cut through this ridge, at many places ... sixty feet over the canal bottom, have rendered it a source of greater anxiety than any other part of the line.

These slides have, in some cases, shewn so slight a yielding at first that they could scarcely be distinguished from sun cracks, but continued gradually to increase for years; in other cases, they have occurred suddenly, and at places where no indications were observed, and in one instance where the bank had been closely covered with sods for a period of over thirteen years.

For the past year the water in the summit level has been kept from 12 to 24 inches higher than the level of Lake Erie, and for several winters past the water has stood in the "Deep Cut" at about the level of Lake Erie. There are a few slight indications of settlements in the lower part of the bank on the north-west side of the canal, but whether they have resulted from the toe of the slope having been removed during the dredging operations, or from similar causes as led to the actual slides and settlements that have taken place, is unknown.

Having provided for a wide berme to be left on both sides of the cut at about 4 feet over the Grand River level, or 12 feet over that of Lake Erie, together with the flat slope given to the face of the banks, it is thought that the tendency to settlement will be greatly diminished; still, there is no certainty that it will be obviated.

It may, however, be stated that at places where heavy slides have taken place on this part of the canal, and have been removed, it is seldom that a slide again occurs at the same place. This has led, as previously mentioned, to the impression that when the yielding materials, which form the lower part of the cut, are displaced to a sufficient depth by the tenacious clay of the sides, there is a probability that the bottom may then remain undisturbed and the subsidence of the banks cease.

The increase of the slopes to some extent lightens the banks, but it exposes a greater inclined area to the action of rains and to the wearing and cutting effects of surface water, which has already made deep furrows in them as well as filled up the ditches formed at the foot of the slopes.

They have now been open to the influence of the atmosphere for several years and they, as well as some of the banks on the Northern Division, might, with advantage, be overhauled next spring, and an attempt made to seed them down with some kind of grass that is known to have a deep wide-spreading root, which, some who are understood to be authorities in such matters state, would, if properly done be likely to grow and answer a good purpose.

Section No. 23.

This section commences near the south end of the "Deep Cut," continues through the Village of Port Robinson, and is altogether about a mile in length. It embraces the construction of abutments and piers for a swing bridge, together with the works, arrangements and equipments necessary for a set of guard gates near the north end of the section; the deepening and widening of the channel; the removal of the abutments of the present swing bridge, and the walls, gates, etc., connected with the old guard lock. (See Appendix No. 16.)

As previously intimated, the object proposed to be gained by the construction of guard gates at Port Robinson, is to have the means of keeping the summit level on the northern part of the canal at its proper height, especially at those places where the banks are of a nature that requires at least the full pressure of the water to sustain them. This is looked upon as absolutely necessary, in case the upper or southern part of the canal should, at any time, be

emptied. In order to accomplish the object fully, and, when required, expeditiously, the guard gates have been placed north of the outlet to the Chippawa River, and, with a view to having persons constantly in attendance there, the abutments and piers for a swing bridge have been built at the same place.

The materials for these works were partly prepared in 1876, but for various reasons (chiefly the necessity of giving public notice in advance and the condition of other works), it was not considered advisable to empty the canal until the winter of 1877 and 1878.

Before the water could be drawn out of the southern part of the canal, a dam had to be formed across the channel a short distance north of where the works for the guard gates are situated.

This the contractor set about in an energetic manner, and with a view to facilitating the operations and lessening the quantity of clay to be put in, he sunk a line of cribs across the canal. The material put in rear of them was of a nature that it got so very soft in the water that it spread over a great distance, and pressed the cribs not only out of line but nearly upset them. In fact the difficulties connected with forming the dam were so numerous that many expressed great doubts of success.

The contractor, however, pushed on day and night until he fully accomplished the object, but then only one stage of the difficulties had been overcome; others of an equally perplexing nature, although less in degree, continued for the greater part of the time that the foundations for the permanent works were in progress.

The weather throughout February, 1878, was unusually mild for the season, still there were frequent heavy rains that acted upon the peculiar spongy nature of the material forming the bottom, (clay mixed with sand) in such a manner that it soon worked into a soft moving mass on which neither horses nor men could travel, until roadways of plank were laid over it. When confined, however, it forms as good a foundation for a structure as any other substance.

After a time these and other unanticipated difficulties were successfully met, and the contemplated works finished in good time for the opening of navigation by the first day of May following.

The water-way of the canal at this place is in four divisions—the two middle openings are each 46 feet in width at the assumed level of Lake Erie, and the side openings are each 18 feet wide. The side walls and centre piers

are of masonry, carried up to a height to form bearings for the swing bridge and fixed structures at both ends of it.

The gate for each opening is in one piece, and the whole is arranged in such a manner that the gates, when not in actual use, occupy a horizontal position in the recesses formed in the bottom for that purpose.

The walls are carried up on a continuous platform of solid timber, tied together horizontally with bolts, and resting on a stratum of concrete fully 18 inches in depth, along each side of which a range of sheet piles was driven, and every precaution adopted to render the whole secure.

All the works connected with the structure have been generally carried out as described in Appendix No. 16, except that the movement of the service dam, at the north end of the enclosed space, rendered it necessary to form the rest piers of white oak piles instead of masonry, and owing to the nature of the bottom, it was considered proper to order a framed crib of timber to be sunk, instead of masonry, for the rest pier of the bridge at the south end.

The stone provided and partly prepared for these piers will require to be taken off the contractors' hands at a fair valuation when a final settlement is made.

The principal works covered by the contract that remain to be done on this section are a few details connected with the new guard gates; the removal of the old swing bridge and its abutments, and the walls, gates, etc., connected with the old guard lock.

The payments made to John Carroll, the contractor for this section, up to the 31st December, 1879, amount in the aggregate to $130,100.

Section No. 24.

This section is situated to the south of Port Robinson, and is about one mile in length. The works upon it consisted chiefly in excavating the channel to a depth of 2¾ feet below the mitre sill of Port Colborne Lock, and to a width of 100 feet at bottom; forming towing path and side banks; cutting ditches, off-take drains, etc. (See Appendix No. 17.)

On this part of the line the channel, for the greater part of the distance, has been widened on the east side, and all the low water-covered spaces on that side have been used as spoil ground, after forming a solid bank next the canal to

keep the soft material in place. Near the south end of the section, the material, as anticipated, was found to be unusually hard.

The whole of the works embraced in the contract have been completed in a satisfactory manner, and the detailed final estimate for them is now in course of preparation.

The payments made to C. F. Dunbar, the contractor for this section, up to the 31st December, 1879, amount in the aggregate to $64,300.

Section No. 25.

On the old canal there were two swing bridges within the limits of this section; one of them, called the Burgar Bridge, was only required as a means of crossing to and from a small extent of land lying between the Chippawa River and the canal.

No public purpose being served by this bridge, it was decided to acquire the land and thereby avoid the necessity of building a new structure at this place—an arrangement to which the Township and County Councils agreed, and authorised the road allowance on the east side of the canal, between the Burgar and Quaker Bridges, to be sold.

This, although a matter of no direct interest to the locality, is of great importance to the navigation, and will save the expense and maintenance of another bridge.

The contract for this section covers the enlargement and deepening of the channel for a distance of fully one mile; forming a line of towing path and banks where required; cutting ditches; removing the abutments, etc., connected with the two swing-bridges over the old canal; the construction of abutments and piers for a bridge over the enlarged channel to carry the traffic of the Quaker Road. (See Appendix No. 17).

The water was drawn down in the summit level as low as it could be done in the winter of 1877–78, in order to get the bridge works on this section, as well as at other places, as far advanced as possible before navigation opened the following spring.

As soon as the place was accessible, the contractors made every possible effort to push on the necessary operations, and continued to do so for some time to as good advantage as could, under the circumstances, be expected; but frequent heavy rains soon made the ground and roads all but impassable for either men or

horses. In the face of these discouraging difficulties, the contractors still persevered and were ultimately successful in getting a large part of the works completed, leaving only those that, from their position and the range of the adjoining ground, admitted of being built advantageously during the following summer.

All the works comprised in the contract, with the exception of some small matters, have been completed.

The payments made up to the 31st December, 1879, to Messrs. Ferguson, Mitchell & Symmes, the contractors for this section, amount in the aggregate to $151,050.

Section No. 26.

The contract for this part of the line, as in most other places on the summit level, comprises the enlargement and deepening of the channel for about a mile in length, the formation of a towing path, cutting ditches, off-take drains, etc. On the lower part of the section, the widening has been taken off both sides, and on the upper two-thirds of it the increased width has been taken wholly off the west side.

The material, although at some places hard, has generally been found easier to excavate than anticipated at the time tenders for the work were invited. This may, however, in some measure, be due to the skilful and energetic manner in which the dredging operations have been conducted.

All the works embraced in the contract are completed, and a detailed estimate of them will, in short time, be ready to enable a final settlement to be made.

The payments made up to the 31st December, 1879, to John Carroll, the contractor for this section, amount to the sum of $83,400.

Section No. 27.

In August, 1877, tenders were received for the execution of the works comprised in this section, which were subsequently awarded to Messrs. Hunter, Murray and Cleveland, and a contract entered into with them in September following. The works are of an extensive and important nature, to the main features of which it is considered proper to draw attention in order following:—

The contract embraces the enlargement of the channel to certain lines suited to the new structures, and the deepening of it to two and three-quarter feet below

the mitre sill of Port Colborne Lock, for a distance of 5,600 feet; the construction of a new aqueduct through the Chippawa River; taking down the greater part of the present lift lock between the river and the canal; building a new lock; removing the abutments of the road bridge that connects the east and west parts of the Town of Welland; constructing abutments and piers for a new swing bridge opposite what is called Division Street; forming a conduit on the east side of the canal to carry the drainage into the Chippawa River at a place below the present aqueduct, etc. (See Appendix No. 18.)

The decision to place the various structures on the summit level and other places, where existing contracts would not be interfered with, at a depth corresponding to a draught of fourteen feet of water, led to a change on this part of the line to which it is necessary again to refer.

In my general report on the subject of the enlargement and deepening of this canal, it will be seen that it was proposed to lower the bottom of the present aqueduct over the Chippawa River, to admit of the passage of vessels drawing twelve feet of water, and to build a separate structure to pass the necessary supply.

To carry out this plan the crown of the arches of the old structure were to be cut down from ten to twelve inches for a space of twenty feet wide in the centre of the channel, and afterwards secured with strong bands of iron let into the stone, etc.

It was then, as now, thought that no greater reduction of the arches could be made with safety, consequently the greater depth of water (14 feet) could not in this way be obtained.

It was therefore considered that the expense of forming an independent means of supply would not be warranted, in view of the construction, at an early period, of a new aqueduct adapted to all the requirements of the enlarged scale of navigation.

These different matters, after due consideration, led to authority being granted to place the works under contract as soon as a design for them could be matured.

The present aqueduct has four arches, each forty feet span and seven feet rise; the centre part of the soffit is fully five feet below the ordinary surface of the water.

In the river, for the greater part of the year, there is little or no current; the water at times is even higher on the east than on the west side of the canal;

but, during snow floods and freshets, a considerable rise frequently takes place on the west or up-stream side.

The river and canal must cross each other in this vicinity, and the latter being the highest, the river must pass under it.

A thorough examination of the locality led to the conclusion that the best, if not the only place that could be judiciously selected for the new aqueduct is in the bed of the iver, at about 75 feet west, or on the up-stream side, and parallel to the present structure.

It is to have six arched openings, which are to be arranged so that the line of the south sides of the second pier from the north side, in both the old and new structures, shall correspond. The arches are to be 40 feet span, and have 7 feet rise; the northern one and the three southern ones are to be circular segments, made to a radius of $32\frac{1}{16}$ feet. The other two arches are to be partly elliptic, at least that side of both of them which springs from the fourth pier from the south side; the springing line of them will be three feet lower, and the pier two feet thicker than any of the others.

It is contemplated to build the new structure at three different times, but in such a manner as to be in two divisions, *i.e.*, to execute the works connected with the four southern arches independently of the two at the north end of the structure. This unavoidable course renders necessary the adoption of certain precautionary measures, in order to meet the thrust of the fourth or northern arch of the first division, by means of vertical and horizontal bars of iron, the details of which will be found on turning to Appendix No. 18.

To enable this plan to be carried out, the channel has been widened out by dredging to such an extent as circumstances would admit, so as to guard against obstructing the water flow of the river, and, at the same time, admit of laying part of the bed of it dry during the time that the works are in progress.

The coffer dams, for the main structure are to be formed in three different sections; the *first section* to enclose the space to be occupied by the three southern arches and piers. The *second section* to include the fourth archway from the south side, together with the piers connected with it, and must be constructed so as to connect with the sides of the *first section* in such a manner as will admit of removing the end of that part of the dam.

The *third section* embraces the space to be occupied by the two northern archways, and will consist of a separate dam to be formed after the water of the river can be turned through the four southern archways.

The *first section* of the dam may be made to include the space for the oblique line of wall between the south-west abutment of the present structure and that of the new work, otherwise a separate dam may be put in for that purpose, etc.

Several ways of constructing these dams are suggested in the documents appended to the contract, either of which the contractors were at liberty to adopt, or indeed any other way likely to occupy the least space consistent with the probability of their success, provided they are made in sections corresponding in extent to those above mentioned.

The contractors to be held responsible for the carrying out of the plan they adopt for the dams, and are to be paid for them the respective amounts stated in their tender, which forms part of the contract.

When putting in the first section of the coffer dams, the contractors were allowed to include the space for the south connecting wall; but from certain indications of settlement in the bank between the old and new works, it was, in April, 1879, considered proper to allow the water to rise in the aqueduct pit.

At this time there appeared to be some misunderstanding between the contractors and the Resident Officer on the subject of the south connecting or oblique wall; a matter that was arranged, after a good deal of discussion, on the 25th April, and their attention drawn to certain clauses in the specification and items in the schedule of rates that seemed to have escaped their notice. A mode of getting over the threatened difficulty was also at the time pointed out, which after a good deal of labor and time occupied in carrying it out, resulted in getting the wall built during the summer.

It may be stated here that the contractors, being held in every way responsible for the coffer dams, naturally expected to be allowed their own way of making them, and they were, of course, desirous of doing it in as economical a manner as possible. Still, as they are bound to maintain the dams and keep the interior space unwatered during the progress of the permanent works, it is to be feared that the desire to lessen the outlay in the first instance has led them to adopt a plan likely to turn out unprofitable to themselves, and unfavorable to the early completion of the undertaking.

It cannot be said that either the dams, as a whole, or their mode of construction ever met such a degree of approval as a belief in their ultimate success would reasonably have warranted.

They have been built for over a year, during which time the enclosed space has been several times laid dry, and part of the bottom excavation done; but it was found necessary to rebuild part of them, and the overhauling of other parts, for the stoppage of leaks, has been a matter of frequent occurrence when the pit has been unwatered; still it cannot be said that confidence in them has materially increased.

The introduction of suitable arrangements for unwatering the pit, and a better system of conducting the operations on the spot cannot, consistently, be much longer delayed.

For the greater part of the past year the contractors have been engaged at the Queenston, Thorold and Beamsville quarries, in getting and preparing stones for the works. At all these places an excellent quality of large-sized gray limestone has been obtained, a considerable quantity of which has been delivered in the vicinity of the works.

The conduit to carry the drainage along the side of the canal, instead of through under it, as heretofore, has been completed, and the road has been raised and macadamized.

The abutments, piers and fender cribs for the new swing bridge have been constructed, and the protection works in the east channel are in place.

On excavating the pit for the new lock between the canal and Chippawa River, it was decided to sink the bottom twelve inches lower than originally contemplated and to lay a stratum of concrete over the entire surface, of the thickness necessary to form a fair bearing for the foundation timbers. The spaces between the timbers, sheet pile trenches at the mitre sill platforms, and at the lock, were also filled with concrete.

The walls have been carried up to about 16 feet over the foundation, the banks in rear of them formed, and the excavation connected with the enlargement of the channel is in a forward state.

The payments made up to the 31st December, 1879, to Messrs. Hunter, Murray & Cleveland, the contractors for this section, amount in the aggregate to $254,800.

Section No. 28.

This section extends from a point about mid-way between the present road-bridge over the canal in the Town of Welland and the bridge for the crossing of the Canada Southern Railway, to 1,500 feet south of the line passing logitudi-

nally through the centre of the Junction lock, making it altogether about 4,970 feet in length.

It comprises the enlargement and deepening of the channel for the distance above stated, the construction of the piers and abutments for a swing bridge south of the junction of the feeder with the main line of the canal, the removal of the old swing bridge, its abutments, fenders, etc. (See Appendix No. 19.)

The abutments and piers for the swing bridge were built during the winter of 1877-78, when the canal was emptied for the purpose of proceeding with this and other works similarly situated. The season was mild, with comparatively little frost; this, together with frequent heavy rains, made it extremely difficult to haul materials to the place; still, the contractors pressed on their operations vigorously until the object was fully accomplished.

The work done is generally of a good class; but the slope wall on the south-west side, from the nature of the material on which it had to be placed, has not stood well, and will require to be overhauled. In the winter of 1877-78 the Canada Southern Railway Company built permanent piers and abutments for the bridge that carries its line over that part of the canal immediately north of the Junction, leaving *two clear* spaces, of the full width required by the Order of the Privy Council in which the authority for the crossing is granted.

It is further stated in the Minute of Council, "That the Company shall "execute, at its sole expense, all the work of excavation necessary to make "and maintain these two channels of a depth suited to canal navigation, as well "as provide for the construction of a centre pier, abutments, guard piers and "other work.

"That both the channels shall be made through the ground occupied by the "Railway, and for such a distance on either side of it as * * * * "may be deemed necessary for the easy and proper passage of vessels."

"That the Company construct and maintain all works directly or indirectly "connected with the bridge, and form such an extent of the channel of the width "and depth required for navigation as the works of the Company may * * * "render necessary, and shall grade a towing path on both sides of the canal "across the space occupied by the bridge or other works connected with it, etc."

The Company did all the work connected with the bridge, and made the necessary channel-ways, on each side of the centre pier, of the full capacity to give the sectional area required, and formed the approaches to the opening on the west side. For the excavation of these approaches, payment is claimed on behalf

of the Company for work represented to have been done outside the railway line. In the permission granted to the Company to cross the canal, there is no mention made of a right to any breadth or length of land, the conditions of occupancy, however, appear to be clearly set forth in the quotations above given In view of these conditions, no positive action has yet been taken in relation to the Railway Company's alleged *claims*.

The works connected with the enlargement and deepening of the channel have been proceeded with at a moderately fair rate since they were commenced, so that the whole will in all probability be completed during the present year.

The payments made up to the 31st December, 1879, to Messrs. Ferguson, Mitchell & Symmes, contractors for this section, amount to $83,400.

SECTIONS NOS. 29 AND 30.

These two sections are each a mile in length; they form separate contracts, but were both awarded to the same firm, Messrs. John Ferguson & Co.

The works upon them consisted wholly of clay excavation. A strip of about 50 feet in width was taken off the west bank, and the bottom of the old canal lowered from 2 to 3 feet throughout. The excavated material was for the most part placed on the west side of the canal at a suitable distance from the water line, a towing path was formed, back ditches cut, etc. (See Appendix No. 20).

Section 29 was completed in the spring of 1877 and a final settlement made with the contractors, Messrs. John Ferguson & Co., who have been paid in full for the work done the sum of $113,247.78

The works on Section No. 30 are also well advanced towards completion. (See Appendix No. 20).

On this section, the line of the Great Western Railway crosses the canal; the privilege to do this was granted to the Company by an Order of the Privy Council on similar terms and conditions as previously mentioned for the Canada Southern Railway.

The works connected with the bridge were undertaken reluctantly by the representatives of the Company, but when once commenced they were urged forward energetically and completed in good time. The east channel was left in fair, passable condition at the opening of navigation on the 1st May, 1878, but

nothing more was done towards forming the west channel or approaches to it than what was absolutely necessary to enable the Company to get the works connected with the bridge piers and abutments constructed.

To get this channel deepened, and the approaches to it formed, the contractors for the section were called upon to do the work, who, as soon as other arrangements would permit, gave it their attention; it seems, however, that according to the conditions on which the privilege of crossing the canal was granted that the expense of completing that part of the channel should be charged to the Great Western Railway Company.

An application has been made by residents of the County of Welland to have a road bridge constructed across the canal, a short distance south of the railway bridge above mentioned, but it is believed that the placing of a ferry scow there, to be used during the season of navigation, would afford all the accommodation that the few residents on the west side of the canal could reasonably expect.

The payments made up to the 31st December, 1879, to Messrs. John Ferguson & Co., for work done on this section amount to the sum of $118,400.

Sections Nos. 31 and 32.

These two sections were let to the late John Brown in one contract; they are fully one mile and three-quarters in length, and, with the exception of a space at Lyons' Creek culvert, comprise the enlargement and deepening of the channel for that distance, the grading of the towing path, cutting side and back ditches etc. (See Appendix No. 20.)

The material excavated was clay throughout, which was placed on the west side of the canal, at a good distance back from the water line, by means of derricks with unusually long booms.

In January, 1877, part of the spoil bank at the south end of section thirty two settled down, and nearly 24,000 cubic yards of the side bank moved forward twenty feet or more into the canal.

It was subsequently ascertained that near the place where this occurred the rock on the west side is only a few feet below the bottom of the new canal, but on the east it is much lower.

This inclination of the rock surface doubtless continues under the west bank which, together with the additional weight put upon it and the lowering of the

water to the level of Lake Erie before the dredged material had been consolidated, all tended to the result above mentioned.

The removal of this slide and the construction of Lyons' Creek Culvert are covered by the contract for Section No. 33, and will be again referred to under that head.

All the works under the contract for Sections Nos. 31 and 32 are completed.

The payments made up to the 31st December, 1879, to the late John Brown and his representatives amount in the aggregate to the sum of $200,100.

Sections Nos. 33 and 34.

Tenders for these sections were received in August, 1877, and the execution of the works was awarded to Ambrose Clark, and a separate contract for each section was made with him in the month of October following.

Section thirty three comprises the enlargement of the channel and the deepening of it to four feet below the top of the mitre sills of the old lock at Port Colborne, building side walls, cutting back ditches and forming other means of drainage, removing a slide from the southern part of Section No. 32, and the construction of an inverted syphon culvert on Section 31, to carry the waters of Lyons' Creek through under the canal.

For about two-thirds of the length of this section the bottom is rock before getting to the full depth required, and for about two-fifths of this distance the surface of the rock varies from nothing to six feet over the bottom line; the other three-fifths varies from six to sixteen feet over the bottom of the enlarged channel. (See Appendix 21.)

Section thirty four is also about a mile in length ; it embraces the enlargement of the channel to a mean width of 124 feet below the low-water line of Lake Erie, and the deepening of it to four feet below the top of the mitre sills of the old lock at Port Colborne ; the construction of abutments and piers for a road bridge on line of Main Street in the Village of Stonebridge, building side walls where required, cutting back ditches, grading towing path, etc.

For the whole length of this section the bottom is in rock cutting, but, for about one-fourth of a mile at the north end of it, the rock will not exceed from 2 to 6 feet in depth above the bottom line. For the other three-fourths of the section the surface of the rock is considerably higher, and at some places it is within 2 feet of the level of the towing path. (See Appendix No. 23).

The contractor for these sections was one of a firm who did a large extent of work at the same place about 35 years ago, and was well known as a reliable and energetic person, but his health failed him, so that he had, in a great measure, to depend upon others conducting the practical part of his business. This resulted in comparatively little being done upon the works during the winter of 1877 .78.

In the summer of 1878, dredging operations and the removal of old spoil bank on Section No. 33 were proceeded with fairly.

In August of that year, the contractor, Ambrose Clark, died; but his executors and others interested in the estate seemed disposed to carry out the undertaking.

In the winter of 1878–79 both sections were unwatered, but beyond this the arrangements were defective, and the operations dragged on in a manner that showed clearly there was no effort made to comply with the conditions of the contract, and that even the comparatively small extent of work done must have been far from profitable.

It is, nevertheless, only fair to state that, by constant pressure on the person managing for the Clark estate, one of the most troublesome pieces of work on the entire line, Lyons' Creek culvert, was commenced and so far completed that winter as not to interfere in any way with the opening of navigation.

The foundation of this culvert is fully 40 feet below the top of the towing path; it is of heavy block stone masonry, the water-way through it is 8 feet wide, side walls 3½ feet high to the springing of the arch, which is made to a radius of 4½ feet.

It is made sufficiently strong, by means of tie rods and otherwise, to be serviceable at all times, even were the canal empty at a time when the greatest head of water pressure is on the culvert. (See pages 265 to 270 of Appendix No. 21.)

It was completed last autumn and is now in use.

The seat for the bridge works on section thirty four has been, for the most part, excavated to the full depth required, and the principal part of the stone and other materials for the abutments, piers. etc, have been delivered, and a good deal of it prepared.

The payments made up to the 31st December, 1879, to the Clark estate, are as follows:—

For work done under contract for Section 33, the sum of ..... $136,300.

For work done on and connected with Section No. 34, the sum of $99,200.

In *May* and *August*, 1879, Mrs. Mary E. Clark, widow of the late Ambrose Clark, sent memorials to the Minister, representing that, since the death of her husband, the works on Sections Nos. 33 and 34 had been carried on under persons, who, although they have an interest in the contract, are incompetent to conduct the operations; moreover, their bad management had caused delay and led to her suffering great pecuniary loss, which she and her family could ill afford, etc.

She, therefore, prayed to be released from the contract, and to get a settlement for the work done, etc.

It having been for a long time evident that some decided course had to be adopted, in order to put matters into a proper shape, it was recommended that possession of them should be taken by the Government, and the whole advertised and re-let, on the understanding that, if the new tenders amounted to more than the works would have done at the previous contract rates, the Government retain the right of charging the whole, or any portion of the additional sum, against the estate of the late Ambrose Clark.

If, at a future time, the executors of the late Mr. Clark can show satisfactorily that all matters relating to the contract for Sections Nos. 33 and 34 are settled between them and the so-called silent partners, and give clear proof of the actual interest that Mrs. Clark had in the contracts, then the Government may determine what portion, if any, of the money withheld from the estate of her late husband can reasonably be refunded to her.

It was then stated, and may be repeated, that the five per cent. security on both contracts amounts to.....	$30,000
Retained per centage on progress estimates, both sections	25,788
Total.....	$55,788
There has also been retained on the item of unwatering the works...	$11,250
Difference between the *pro rata* rates allowed in progress estimates and the contract rates.....	13,254
Total.....	$24,504

The contractors, although not entitled to be paid any part of the latter sum, ($24,504), still the estate should be credited with it when considering the question of additional cost, if the result renders this course necessary.

A minute of the Honorable the Privy Council, dated the 25th August, 1879, authorized the works to be taken possession of, and the completion of them re-let.

In October following, both sections were advertised, and tenders for them received in November.

Section No. 33 was subsequently awarded to Messrs. Bannerman & Co., and a contract made with that firm in December last. It comprises the completion of all the works covered by the original contract, except the culvert at Lyons' Creek, which the representatives of the Clark estate have finished. (See Appendix No. 22.)

Section No. 34 was awarded to F. B. McNamee & Co., and a contract made with that firm in December. It provides for the completion of all the work embraced in the original contract. (See Appendix No. 23.)

Both these sections are unwatered, and the works upon them are now in progress.

SECTION NO. 35.

This section is fully two-fifths of a mile in length, and situated within the boundaries of the Corporation of Port Colborne, it embraces the enlargement of the canal, for a distance of fully one-third of a mile, to a mean width of 124 feet below low-water line of Lake Erie, and deepening it to 4 feet below the top of the mitre sills of the old lock; the construction of a new entrance lock to and from the harbor, the southern wings of which are to be extended to form piers and abutments for a road bridge, and the north-east wing made of a length to form an abutment, and the north-west wing made to form part of the centre pier for a bridge crossing for the Grand Trunk Railway.

It also embraces the formation of a raceway in two divisions, one of them open, the other arched over, and both faced with masonry; building a weir arranged to supply the greater part of the volume of water required for the enlarged canal; constructing temporary road bridges; grading towing path and roads, etc. (See Appendix No. 24).

When endeavoring to arrive at the best way of carrying out the scheme of enlargement at this place, it was found that the comparatively narrow space reserved for the canal through the village left little choice as to the mode of accomplishing the object.

It may be observed that when Lake Erie forms the source of supply, the level north of the guard lock at ordinary times will be the same height as that to the south of it.

To provide for this at all times, but especially at periods of extreme low water in the lake, renders a wide supply-race indispensable, for the formation of which in the usual way there was not sufficient space.

It was therefore decided that it should occupy the whole space between the west side of the old lock and the west line of what is called West Street, and that it should be in two divisions—the one next the lock to be open, and the western one arched over in a manner to admit of it being used for a street. The east wall to be carried up to the level of the street and finished with a proper coping on top, along which a suitable railing is to be placed for the safety of the public. The supply weir constructed at the north end of the raceway is to have five openings, in each of which are to be combined movable bulk-heads and sluices to regulate the supply.

The raceway at the ordinary height of the lake is of sufficient capacity to pass the full volume of water required, and at extreme low water it can be supplemented by passing a small part of the supply through the old lock.

The new lock is placed on the east of the old structure in such a position that the south gates in both of them are directly opposite each other, and the centre lines through the respective locks are 74 feet apart at the south gates and 72 feet apart at the north gates of the old lock.

The north-east wing of the new structure is extended so as to form an abutment to the Grand Trunk Railway bridge, and the north-west wing of the new lock and the north-east wing of the old one are continued in a slightly oblique direction, until they form one wall, at the place required for a rest pier to the same bridge.

To enable the lock to be built in this position, and, at the same time, have sufficient space for a street on the east side of it, a considerable extent of property had to be acquired.

In this connection it may be stated that there has been much inconvenience experienced by the contractors and by the public from certain parts of the canal lands in that vicinity being occupied by squatters, who are exceedingly unwilling to give it up unless in some way compensated. It is extremely strange to the uninitiated to learn that possession can be taken of private property in forty eight hours for a public work, but that possession cannot be obtained in as many weeks of property belonging to the Government.

The enlargement of this part of the canal renders necessary a considerable change in the Grand Trunk Railway bridge-crossing, at this place, a question to which attention was drawn in a previous special report, and the fact pointed out that there had been great irregularity in this matter by the B. & L. H. R. Company who constructed the road. The subject was shortly afterwards brought under the notice of J. Hickson, Esq, the general manager of the G. T. R., who, after making the necessary inquiries into the matter, admitted that it stood nearly as represented in the report above mentioned.

This candid admission, together with an evident desire of doing what was right under the circumstances, led to an arrangement being made for the Department to construct the centre pier and abutments for the bridge, and for the Railway Company to provide and fit up the superstructure, and also form a temporary means of crossing the canal whilst the works are in progress.

This agreement is now in course of being carried out; the Railway Company have made a temporary crossing, and the other works are in progress, so that there is every reason to believe the whole will be completed and in use by the first day of May next.

The greater part of the lock walls have been carried up to 16½ feet in height, but the south wing walls and the abutments for the public road crossing have not been commenced.

The works connected with the regulating weir and raceway are well advanced, and the operations generally on the section are in a forward state.

The payments made up to the 31st December, 1879, to the contractors, Messrs. Hunter, Murray & Cleveland, amount to the sum of $276,200.

Section No. 36.

The contract for this section comprises all the works connected with the enlargement and deepening of Port Colborne Harbor, or Lake Erie entrance to the canal, the main features of which may be briefly described as follows:—

The extension of the west pier four hundred feet farther into the lake, deepening the entrance channel, rebuilding the superstructure of both the east and west piers, constructing a beacon in the lake on the south-east side of the entrance, and building four detached blocks of pier work between it and the end of the east pier, removing the old west docking from the ferry recess outward and rebuilding it at a lower level, deepening and enlarging the basin, etc. (See Appendix No. 25.)

All the works covered by the contract are completed, with the exception of the removal of some high points found in the channel, which can be done in a comparatively short time, when the weather is favorable.

The inner basin or harbor is fully 2,000 feet long, and has a width of nearly 250 feet at the narrowest place.

The approach or channel leading into it is 450 feet wide opposite the outer end of the west pier, and 150 feet wide at the inner end.

This funnel-shaped approach tends to make smoother water in the harbor and the unfavorable effects that might, otherwise, result from it are lessened by the openings between the detached blocks of pier work on the east side allowing the water to escape on that side.

The channel from the lake, northward, to the southern line of the basin has been sunk, with the exceptions above stated, to a depth of seventeen feet below low-water line; and, from the latter place to the north end of the basin, the depth gradually diminishes to sixteen feet below the line of twelve feet water over the mitre sills of the old lock.

In the enlargement and deepening of the harbor and entrance to it, fully one-sixth of the quantity of material removed has been a hard class of rock with numerous nodules of flint in it.

The works, as a whole, have been energetically and skilfully managed, and the contractor has manifested throughout a desire to carry out in every respect the conditions of the agreement.

The beacon is about 47 feet high over the water, it is visible a considerable distance out in the lake, and is found to be a much surer guide to vessels entering the harbor than the buoy that was formerly anchored near that place.

The Marine Department has constructed a leading light on the outer end of the west pier, and a range light on one of the detached blocks of pier work, situated on the east side of the channel, at some distance from the shore. Thus the entrance to the canal is now, at all times, well defined.

The payments made up to the 31st December, 1879, to C. F. Dunbar, the contractor for Section No. 36, amount to the sum of $456,750.

Between Port Dalhousie and Port Colborne there will be *twenty-four* bridges over the canal. Five of them are railway crossings; one the property of the Grand Trunk Railway Company; one belongs to the Great Western Railway; one is owned by the Canada Southern Railway Company, and two are to be constructed by this Department as crossings for the Welland Railway. There are eleven separate or detached road bridges; five over the upper wing walls of locks, and three over the lower wings of locks.

At all the railway and detached bridges, the water-way is in four divisions, which in the aggregate have a sectional area equal to that of the canal, except the Canada Southern Railway bridge, where the full sectional area is obtained by forming greater spans.

The two centre openings are each forty six feet wide, and are to form the navigable channels.

The piers and abutments are of masonry, laid in hydraulic cement mortar, on a foundation of timber and plank placed one foot below canal bottom. The centre and rest piers of detached bridges are invariably parallel to the centre line of the canal; the former from 16 to 18 feet square, and the latter from 15 to 17 feet in width and 9 feet in thickness, and in all cases an arched culvert, varying from 6 to 8 feet in width and 8 feet in height, is made through the centre of them, on a line ranging with that of the canal. The piers to form the seat of the swing portion of the bridge and the abutments are also of masonry.

Stone parapet piers are carried up at all the four corners of all the bridges, one of which, at each end of the detached bridges, is hollowed out to receive machinery, and the wings of the abutments are carried up to the same height as the parapet piers.

Between the centre and rest piers, as well as above and below them, crib work is constructed to form bearings for fenders on each side, and for the protection of the respective parts of the work. Through the middle of the cribs, longitudinally, a clear water-way is formed, and transverse openings are also made adjoining the centre and rest piers and elsewhere, of such shape and dimensions as, together with the centre openings, give an area equal to at least that of the archways formed in the masonry.

The seat piers are protected by means of piles or framed bents, sunk into the bottom, on which strong cap-pieces are secured, and connected with suitable anchor timbers let into the bank.

For the protection of the structure and guide piers, clusters of piles are driven—within the range of the centre and rest pier—at suitable distances above and below them.

The superstructures of all the road bridges are to be on the "Howe Truss" principle. The movable portion of detached structures will be made of a length to span the two navigable channels, and those at locks are to have a short arm, and be balanced by weight put on for that purpose.

A general plan for both kinds of structures will be found hereto appended marked "Sheet E."

In all cases the lower chords, floor beams and stringers are to be of wrought iron, formed in pieces of uniform and convenient length, and so arranged that they can be readily replaced in case of accident.

The top chords, diagonal braces and such stringers as required to fasten the flooring to, are to be of timber.

By this arrangement, those parts of the bridges most liable to accident can be readily repaired or replaced by the workmen usually employed on the canal. Besides provision being made for the floor system, which is the most subject to decay, to be of iron, the structures will be more durable, and at the same time possess all the advantages that could be derived from a bridge built chiefly of wood.

The "Galley Frames," to form centre bearings for the suspension cables, are to be of wood and iron combined, and on the cross beams between them, a signal light can be exhibited to serve for both road and canal.

For the safety of the public, it is intended that a self-acting gate shall bar the road-way when a bridge is open for the passage of vessels, and which will not be wholly removed until the bridge is again in position, when a crossing can be safely made.

This gate will also serve the purpose of carrying the towing lines over the parapets and raised portions of the stationary parts of the structure.

The machinery for turning the bridge will be placed on one side of the centre, and so arranged that it can be readily worked by one person.

In all cases the turntables will be of the same pattern, and the respective principal parts of the superstructure of all the bridges will be alike, so that to

keep a comparatively small supply on hand, of the different parts of each kind, will be likely to meet all the requirements.

The fixed part of the road-way over the side-channels is to be formed by means of joists, on which to carry and fasten the floor plank; there is also to be a rolled girder on each side and a hand-rail on top, with a truss between them.

Oak and pine timber for all the lock gates on the line, together with three full sets of spare gates, making, in all, timber for sixty one pairs of gates was delivered last autumn near Merritton, and placed under cover on canal property.

It is all of the best class of the respective kinds, generally sawn to the sizes required. Owing to the large dimensions of the timber and the low rates at which the furnishing of it was undertaken, especially the price for pine, there was considerable difficulty experienced in procuring it.

This led to some delay in its delivery. The contractor, however, deserves credit for his determined perseverance under rather discouraging circumstances, and his readiness in all other respects to comply with the terms of the contract.

In November last a settlement in full was made with the contractor for this timber, David S. Booth, which in the aggregate amounted to $113,253.51.

From the foregoing representation of matters connected with the works on this canal, it will be seen that, with the exception of changing the line of the Great Western Railway, Section No. 12, the completion of Sections Nos. 33 and 34, and the aqueduct over or through the Chippawa River; the whole are in an advanced state.

The extension of the railway line, when once undertaken, can be proceeded with rapidly, and Sections Nos. 33 and 34, can also be carried on expeditiously; but the aqueduct seems not only to drag along in a tedious way, but, as before stated, the coffer dams are not such as to inspire confidence in their accomplishing the object contemplated in their construction. This is the more to be regretted, as on the completion of this structure depends the bringing into use all the new locks and other works on the enlarged line of canal.

BURLINGTON BAY CANAL.

At the last session of the Legislature the sum of $12,000 was granted towards "rebuilding superstructure of north-west pier, Burlington Bay Canal, destroyed by fire."

On visiting the place with a view of getting such information as would enable the works to be placed under contract, it was found that for a distance of about 1,100 feet of the inner or bay end of the north-west pier, the side timbers, &c., were burnt down to the water line, but that the greater part of the ballast still remained in position. The top covering is rotten at many places on other parts of the piers, and the waling generally is decayed, and long stretches of it are gone.

At several places on the south-east pier, the ballast has been washed out, and at the bay end on that side the pier has settled, and part of the superstructure there is in a ruinous condition. It is probable that this settlement may, to some extent, result from the scouring of the bottom, by the action of the water when vessels that use it as a landing wharf are leaving.

In August last, tenders were received for the repairs, when the works were awarded to D. McDermid and John S. Hendrie, and a contract entered into with them in September, but up to the present time none of the repairs have been done, although the contractors have kept up a considerable correspondence with the Department on the subject.

To guard as much as possible against fire, in future the top of the inner or bay half of the pier is to be covered with fine gravel, instead of plank, as heretofore. (See Appendix No. 27.)

GALOPS RAPID.

At low stages of the River St. Lawrence, the shoals in this rapid form an obstruction to the passage of vessels of even light draught, which may fairly be viewed as an objectionable feature of the route that should, if possible, in some way, be remedied.

The accomplishment of this object assumes greater importance when the fact is borne in mind that vessels, at ordinary water, can pass down the river, from the head of the rapid to Dickinson's Landing, in less than one-third of the time it requires to pass through the Williamsburg canals. This is especially noticeable when contrasted with periods of extreme low water, during which advantage cannot be taken of the river route.

In the past 60 years, the extreme variation of the normal water levels of Lakes Erie and Ontario has been known to be about 5½ feet; but there has been no absolute change perceptible in the mean water level within the time stated.

The lowest water in the lakes of which any record could be found appears to have been in 1819, 1848, 1872 and 1877. The highest water in Lake Ontario within the period mentioned was in 1838, 1853, 1859, 1862, 1870 and 1876.

At Port Colborne, Lake Erie, in April, 1859, the water was 7 feet 10 inches higher than it was in November, 1872.

In June, 1870, the water level at Port Dalhousie was 5 feet 5 inches over the level of November, 1872; and in May, 1870, the water in the bay at Toronto was 5 feet 3½ inches higher than it was on the 19th March, 1872.

The water level in 1877 was not as low as that in 1872; neither was the water level of 1876 as high as that in 1870. It may be here stated that the variations of the water levels at different places on the river are not, in all cases, the same; neither do they correspond with those on the lakes. Long, wide and nearly level stretches of the river appear to be less subject to variations (ice jams excepted) than where the width is less and the reaches comparatively short.

On turning to a report submitted by me in July, 1874, on the navigation of the River St. Lawrence between Lake Ontario and Montreal, it will be seen that an attempt was made to put all reliable information that could be collected relative to the fluctuations of the river in such order and form as was believed might be of service in enabling a conclusion to be arrived at on the subject.

Within the past 30 years several schemes have been proposed with a view to increasing the depth of water in the channels through the different rapids, none of which, however, is or can be expected to be free from objections. It has, therefore, been assumed that the plan presenting the greatest probability of success in producing permanent results, although attended with more than ordinary difficulties in its execution, would be the best under the circumstances to adopt.

This, after considering the subject in all its known bearings and in every way that it presents itself, has led to the conclusion that the deepening of the bed of the river would be the most likely to fulfil these conditions.

But before any attempt to execute the work could be made, it was absolutely necessary to know the nature and extent of what had to be done, and to

provide the means of obtaining full information on these matters. It was well known that in the Galops Rapid the most powerful steamer could not remain long enough in one place to enable even the depth of the water, with any degree of certainty, to be correctly ascertained. It therefore became necessary to construct and fit up a vessel in such a manner that it could be held steadily in position at any place. For this purpose a powerful steam vessel, working upon a chain made fast on the shore, seemed to be the best, if not the only way of accomplishing the object. Moreover, it was then, as well as now, thought that the equipment of the vessel might be such that the principal operations connected with the deepening of the channel might be carried on on board of it.

Arrangements were therefore made for the construction of a "Chain Vessel" of such capacity as it was thought would be fully equal to the service required.

The vessel built is 112 feet long, 27 feet breadth of beam, and draws about five feet of water, with fuel on board; it is built in the most substantial manner, with double frames of white oak timber, and fastened in every way likely to give strength and security. The engines are high pressure and condensing, with two cylinders 22 inches diameter and five feet stroke. They are built strong and fitted up with all the latest improvements and equipments.

The two boilers with which it is supplied are of the best description of material and workmanship, and of ample capacity for supplying all the steam required for the engines, drills and other purposes, etc. (See Appendix No. 28.)

During the time that the vessel, engines, boilers, etc., were in course of construction, a chain was made to order for it in England, with links of a special length to work over sprockets. It is of the very best description of 1¼-inch iron, and was properly tested before it was shipped.

After the vessel, chain, etc., were delivered, they were soon got into position; but it was some time before the officers in charge were able to control the vessel in the eddies and oblique currents.

Consequently, it was near the close of season of navigation before arrangements could be made to test the drilling operations on the line of the contemplated channel. Sufficiently close soundings and examinations were, however, made to enable a tolerably fair idea to be formed of what has to be done in order to form a channel on the line and of the capacity required.

All of which leads to the conclusion that the best, if not the only, way of obtaining a channel suited to the enlarged scale of navigation is that of lowering

the shoals and bars on the line, and dragging or in some other way moving the loosened material into deep water below the places where the obstructions occur.

It may be again said that, although the depth of water in a rapid will not increase to the same extent as that to which the bottom is lowered, the difference will have something like the ratio that the additional sectional area, given to the channel formed, has to that part of the river where the deepening has taken place, which, in the case under consideration, will be inappreciable.

Having ascertained that the vessel could be kept sufficiently steady in the rapid to admit of drilling and other operations being carried on, and that a fair knowledge of the bed of the river had been obtained, it was recommended that tenders be invited for the execution of the works, and that the contractor should be allowed, under certain conditions, the use of the chain vessel that had been provided and fitted up chiefly for that purpose.

Tenders were accordingly invited by public notice, and received in September 1878, but in February, 1879, the guarantee money was returned to the tenderers without any award having been made. The works were, however, subsequently awarded to Messrs. William Davis & Sons, and a contract entered into with them in August, 1879.

The contract comprises the deepening, and otherwise forming a nearly straight channel, 200 feet in width, through that part of the Galops Rapid, from a point abreast of the extreme upper end of the entrance pier to the Galops Canal, and extending downward to deep water below the bar, or to opposite what is called Cold Spring Bay.

There are six different places, within a distance of about *five-eighths* of a mile, where widening or deepening has to be done. The "Lower Bar" and "Island Shoal" are to be made 17 feet in depth, and other places 16 feet in depth below the inclined surface of the river at a time when there is 9 feet of water on the mitre sills of the guard lock of the Galops Canal. Parties tendering were informed that to effect the contemplated object, the operations must throughout be conducted in an unusually rapid current, which, at some places runs obliquely across the contemplated line of improvements. Besides that, interruptions were almost certain to be experienced from the passage of both upward and downward-bound vessels, and large rafts of timbers descending, especially such of them as might not be under proper control.

In short, it being looked upon as an exceptionally difficult undertaking, it was considered proper to state all that was positively known in relation to it,

in order to avoid, if possible, future misunderstanding on the subject. (See Appendix No. 29.)

The contractors have insured the vessel, and taken it to Montreal with a view of making such alterations as will, in their opinion, better adapt it to the mode proposed to be adopted in executing the works.

They have since been successful in securing the services of a skilful person to make the necessary arrangements, and to conduct, in the rapid, all the practical operations connected with the undertaking.

Before proceeding downwards, it is considered proper to remark that, from Prescott to near what is called Pier Island, the channel of the river is sufficiently deep; but between the latter place and Adams' Island, in a northerly direction, there is a stretch of about 2,000 feet in which the depth of water varies from ten and a half to thirteen feet when there is nine feet of water on the mitre sills of the guard lock. Further to the eastward, or nearer to Adams' Island, on the same stretch, the water is deeper, but the current is very strong.

The bottom of the river at this place is limestone with a comparatively smooth surface, but on it there are at places patches of boulders and loose rock.

The deepening of this part of the channel, it is thought, could now be done for a much less amount than stated on page 28 of my report of July, 1874, labor of every kind being much higher at that time than it is now; besides, contractors are getting better acquainted with the mode of conducting submarine rock excavation.

After passing the Galops Rapid, the next place in descending order where a shoal was found is about two miles below the foot of Rapide Plat Canal, near "Willards," where there are large accumulations of boulder stone, etc.

At this place a considerable improvement could be made by the removal of part of this shoal, still it is not absolutely necessary, as there is a channel in the vicinity sufficiently deep, although it is slightly crooked and indirect.

At several places on the line of the St. Lawrence Canals, great anxiety is felt by those interested in water power, from the probability that exists of their being deprived of the use of it at recurrent periods of low water in the river.

Nevertheless, the desire to get water power by others is, if possible, still greater, even where it is well known that the supply is limited at the ordinary height of the water.

At the time the St. Lawrence Canals were constructed there appears to have been no possibility of obtaining anything like reliable information relative to the fluctuations of the river, as the upper entrance of none of them are of a depth suited to low water.

The depth of water on the lock sills at the respective places mentioned below was, in October, 1872, as follows :—

—	Galops Guard Lock.	Lower Entrance Iroquois Canal.	Rapide Plat Guard Lock.	Lower Entrance Rapide Plat Canal.	Farran's Point Canal.	Cornwall Canal Guard Lock.	Lower Entrance Cornwall Canal.	Beauharnois Canal Guard Lock.	Lower Entrance Beauharnois Canal.	Lachine Canal Guard Lock.
Lock.....	27	25	24	23	22	21	15	14	6	5
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	8 1	9 3	6 7	7 0	7 9	8 3	9 0	10 10	9 3	9 4

In October, 1877, the depth was from 1 to 4 inches more on the lock sills at the places above named.

From the foregoing table it will be seen that Rapide Plat Canal, at the time stated (Oct. 1872), was nearly 2½ feet lower than at a time when there is 9 feet water on the sills of the guard lock.

It is true this extreme low water was not of long continuance, still it only reached the 9 feet line that year for a few days in the month of July.

Consequently the lessees of water power at the lower end of this canal could have had no supply whatever for the greater part of the season, if the interests of navigation were fully considered.

When the enlargement of this division of the canals is decided upon, if the question of additional water power upon it is to be considered, the best way of effecting this object should, of course, be adopted.

It will be seen (Appendix No. 30) that the distance between the head of of Rapide Plat Canal and Point Iroquois, is a little over four miles, and that the surface inclination of the river is about three and a half feet.

By continuing a bank up the river, the height of water might be increased at the rate of about *one* foot for every three-quarters of a mile of bank formed

This would probably cost at the rate of fully $160,000 per mile, or four times the sum it would take to deepen the whole of the canal one foot.

To obtain a little over two feet in depth at low water in this way, if possible to do it at all, would cost not less than $350,000, or fully as much as to deepen the entire canal from 5½ to 6 feet; nevertheless, after the extension was made and two feet depth of water gained, there would still remain from 3½ to 4 feet of material to be taken out of the bottom of the canal.

It is true that to raise the whole surface level of the canal would increase the head of water at Morrisburgh and thereby benefit the water power interest, but it is to be feared this advantage would have to be purchased at a higher rate than circumstances would warrant.

There is good reason to believe that the least expensive way of increasing the capacity of the canal is to widen and deepen it, and to form a wide supply or regulating weir at the upper entrance. If the water power question is to be considered in this case, the bottom could be sunk sufficiently deep to allow the water below the guard lock to be drawn down ten or twelve inches, without detriment to the navigation. This, at the time of low water, would reduce the head, for milling purposes, at Morrisburgh to about 8 feet (unless the wheels were made adjustable) and increase the probable cost about $35,000.

For further details relative to the scheme of enlargement, position of new locks, etc., on this and other divisions of the Williamsburg Canal, attention is invited to Appendix No. 30, where an estimate of the probable cost of enlargement will also be found.

CORNWALL CANAL.

In July, 1874, a moderately full report on this canal was submitted, giving general details of what would have to be done to enlarge and deepen it for the passage of vessels drawing twelve feet of water. This paper it has been considered proper to reprint (see Appendix No. 31), as it contains information that it took a considerable time to collect and prepare, and to which the attention of the Department has been recently called by the lessees of water power at Cornwall.

It will be seen that the subject is discussed under the original instructions, *i.e.*, for a twelve feet line of navigation, in which it is intimated that the water between Locks Nos. 18 and 19 might be raised to give the dimensions required

for the channel, and that the locks be enlarged by lengthening and raising the side walls.

The arch of the culvert for the road leading to Barnhart's Island is represented to be of a height that would admit of lowering the bottom of the channel, but it would have to be lengthened to obtain the necessary width of water-way whether the level be raised or the bottom lowered.

Further, it was stated that by lowering the bottom and arches, and lengthening the culverts at Mille Roches and Moulinette, they might continue to answer the purpose, although in a less efficient way.

The circumstances are now, however, quite changed; by increasing the depth to 14 feet, it will be necessary to widen and deepen the channel from Lock No. 18, upwards, to deep water at the entrance, and to construct new locks throughout the entire line. The culverts must be closed, and where the crossing is of importance a swing bridge will have to be built.

On reference to a table given on a preceeding page, it will been seen that in October, 1872, the water stood on the sills of the entrance lock to this canal at 8¼ feet; in October, 1877, it was 8⅔ feet, and it may be added that the water level of the river has been frequently, for a considerable length of time, 9 feet on the lock sills, or at the same height above and below the guard gates.

At the lower end of the canal there are water powers leased and granted, estimated to drive 36 runs of ordinary mill stones, equal to at least 360 nominal horse power, but it is quite likely that a much larger quantity of water is used, and all drawn from the level immediately opposite the town of Cornwall.

The only means at present of admitting the water supply at the head of the canal is through a raceway 28 feet in width, together with what can pass through the guard lock. It is, therefore, quite clear that at the time of low water the navigation must suffer, and the lessees of the surplus water, for a considerable time, be obliged to stop their machinery.

A few years ago a pier of crib work was extended up stream 325 feet above the upper end of the river bank, which had the effect of greatly improving the entrance to the canal as well as of raising the water above the guard lock fully *five inches*. But the surface inclination of the river for a long distance above the pier is now very slight, so that very little rise of the water inside could possibly result from any further reasonable extension of the pier, clearly indicating that to obtain the contemplated depth of water the upper or summit level of the canal must be lowered.

In order to get a greater volume of water through it at periods when the river is low, the bottom must be sunk sufficiently to admit of the level being reduced at these times from 10 to 12 inches, without interfering with the navigation.

This scheme could not be carried out advantageously with the guard lock in its present position; it is therefore believed that a new structure should be built about *a quarter of a mile* above the present one and in such a position as to be on one side of the centre line, so as to admit of the construction of a weir wide enough to furnish the supply when the river is low.

At the place mentioned there is a bend in the line and the ground is of less height than to the eastward; to secure sufficient width for the lock and supply-race it is proposed to cut off 50 feet or more on the north-west or convex side of the channel, and form a coffer dam, so as to be able to build the lock in summer, during the progress of which vessels will pass on the other side of the canal. The weir can be built in the winter and spring following.

To enlarge the canal and deepen it to fifteen feet below the lowest known stages of the river, from the upper entrance downwards to about 200 feet below the present guard gates, construct a new lock and weir, would cost from $260,000 to $300,000. It would, however, form part of the scheme of enlargement, and would enable the large factories at Cornwall to be carried on without the constant dread of having to stop when the river is low.

Section No. 1 at the lower end of this canal was awarded to Messrs. Gordon, Woodward & Chamberlin, and a contract was entered into with them in August, 1876. It is an entirely new work, fully 300 feet south of the old line; it was the first part of the enlargement undertaken, chiefly for the reason that the spaces between the locks on the old canal are insufficient to allow vessels, going in different directions, to pass each other freely in the two lowest reaches. This, in busy times, has been always found to be a great inconvenience and has frequently resulted in considerable delay.

It was, therefore, decided that instead of having three locks between the river and the Cornwall reach, the difference of level (24 feet), should, on the new part of the line, be overcome by means of two locks, in order to allow ample space for vessels to pass each other in the reach between them.

The lower or entrance lock on the new part of the line is placed in a position that its lower gates are opposite the upper gates of the present outlet lock, and

the lower quoins of the second lock are opposite the head gates of the third lock of the old canal.

A regulating weir and raceway are constructed on the south side of the new line, the weir is opposite the lower gates of the second lock, and the head race to it connects with the canal at a place about 250 feet above the lock. The tail from the weir has been kept a height, to supply the reach between the locks, and from it a tail race is intended to be formed of sufficient capacity to discharge the surplus water into the river.

The lessees of water power, in a memorial to the Department, ask the level of the Cornwall reach to be raised, when enlarging the capacity of the canal, representing that this would be of great advantage to them at times when ice jams occur. This was agreed to, provided that satisfactory arrangements could be made with the parties interested in the adjoining property and with the water power lessees, to raise certain parts of the banks, reconstruct their flumes and do all such works outside the line of the canal as may be necessary to accomplish the object. (See Appendix No. 32).

On excavating the pits for the locks, the bottoms of them were found to be more solid and compact than indicated by the test pits sunk previous to placing the works under contract. This is especially the case at the place where the lower lock is situated, the bottom being of a moderately hard and uniform nature throughout; but the bottom of the upper lock was more irregular, with boulder stones interpersed, and springs of water at several places; still it was found that, in order to keep the respective pits dry, there was less water to be disposed of than anticipated.

The material was, however, of a nature that rendered it necessary to form a bearing surface for the foundation timbers of hydraulic cement concrete, a stratum of which, twelve inches in depth, was laid over the entire bottom and all the spaces between the floor timbers, also the trenches cut for sheet piles were made up with concrete.

The masonry of the weir and raceway has been completed for some time. The masonry of the locks, with the exception of preparing and laying the coping stone, is nearly finished.

There still remain a number of details to be attended to, such as the carrying up of the superstructure of the south pier at the lower entrance, extension of the wings of the locks, building slope wall on north side of the basin, etc., etc.

The raising of the walls of Lock No. 17, and those of the supply weir to the mills has not yet been commenced. See the report of the resident officer Mr. Rubidge. (Appendix No. 33.)

The payments made to Messrs. Gordon, Woodward & Chamberlin, contractors for this section, up to the 31st December last, amount in the aggregate to $386,480.

Oak timber for the gates of the two locks on this section, together with that for a set of spare gates, has been delivered by D. S. Booth, contractor, for which has been paid the sum of $4,076.82.

The pine timber necessary to complete the gates has recently been placed under contract.

In 1872 and 1873 the channels through Lake St. Francis and Lake St. Louis were carefully surveyed, closely sounded and examined, and in 1874 a report on the subject was submitted, extracts from which it has been considered advisable to reprint. (See Appendix No. 34.)

From these it will be seen that, although there are a few shoal places, none of them are of a nature or extent that can be viewed as presenting any great difficulty in the way of obtaining a channel of the full depth required.

In Lake St. Francis the shoals above the entrance to the Beauharnois Canal are by far the greatest impediments in the way of accomplishing the object; in quantity they are fully seven times greater than all the others put together, and the proportion is much greater when the nature of the material of which they are respectively composed is considered.

The deep water channel of the river, it may be stated, towards the lower end of the lake, is mainly on the north side.

On Lake St. Louis the only obstruction to the passage of vessels, of the contemplated draught, is within a stretch of about four miles and in the vicinity of the light ships, where there are a series of detached shoals with deep water spaces between them, but so situated that there is no continuous channel adapted to the enlarged scale of navigation. It may, however, be stated that there is really no great difficulty in forming a channel of the capacity required, and that when the expense and its probable advantages are fairly considered, the impression increases that the improvement might judiciously be undertaken.

The cities and towns on Lake Ontario require coal, which cannot profitably be carried through the Gulf of the St. Lawrence in vessels of less draught than 14 feet; this introduces an element only second in importance to the downward transportation of grain. At all events it is a matter that should not be overlooked, as is frequently done, by those who profess to be able to give opinions on this subject.

LACHINE CANAL.

The length and dimensions of this canal, previous to its enlargement, and the number of locks upon it, as well as a similar class of information relative to all the other St. Lawrence canals, having been frequently given in the reports of the Department of Public Works, it is not considered necessary to repeat here what may be found in any of the annual documents printed within the past sixteen years.

Before treating of matters directly connected with the works of enlargement, it is believed of importance to reproduce a few facts bearing on questions that have often occupied, and must ere long again occupy the attention of the Department in charge of this branch of the public service.

On the second basin above the outlet of the Lachine Canal, which is fully twenty two feet over the ordinary summer water level of the river or harbor of Montreal, surplus water sufficient to propel sixty five runs of mill stones has been leased, the greater part of which is in use. But none of the leases give either the sectional area of the volume of water to be used, or the measure of power applicable to a "run of stones."

This omission has led to the lessees using a very large quantity of water, and to contend that they have a right to the use of sufficient water to drive the number of millstones stated in their respective leases, without reference to the volume "of water or power required for that purpose." Relative to this, it has been urged that, as the original calculation on which the water power was leased was based upon ten effective horse power as the maximum for a run of stones, the lessees are not entitled to any more.

These conflicting opinions led to inquiries being made in regard to the course adopted at other places similarly situated, the result of which did not lead to any satisfactory solution of the matter, beyond the fact that mill-owners represent that the power required for a run of stones, in an ordinary grist mill, is insufficient to propel a run of millstones at a velocity and power adapted to a modern merchant mill, such as some of those now in use at Montreal.

It is only a part of the water power leased, probably one-third, that is applied to driving flouring mills; still the leases are in all cases nearly the same, and the lessees claim equal rights as to the volume of water used.

Thus a comparatively small rent is obtained, and probably double the quantity of water used that was intended to be granted by the Government, or even expected by the lessees, at the time when the leases were first made.

This, before the enlargement, was found frequently to interfere greatly with the efficiency of the canal; and, although less liable to do so now, still the fact remains that some are using more than twenty horse power to a run of stones—a state of matters that should be arranged by either increasing the rental or diminishing the inordinate consumption of water. In the latter case, applicants for water power who have been hitherto refused could then be supplied, and in either case the revenue from that source would be increased.

The surplus water passing at the 3rd or St. Gabriel Lock, stated to be not less than 20 runs of stones, together with certain lands, were leased in 1851 to a company at an annual rental of $1,680.

At that time, and prior to it, the available water power appears to have been estimated as equal to thirty six runs of millstones, of ten horse power each.

The lessees have from time to time sub-leased water for nearly triple the largest number of runs of stones above mentioned, the greater number of which are at times in full operation.

Questions arising out of this excessive quantity of water drawn off the canal, for milling purposes, formed a case submitted to the provincial arbitrators about eighteen years ago, who, after meeting, heard a great number of witnesses, consisting of captains and pilots of vessels, mill-owners, hydraulic engineers, etc. But, before a decision was arrived at, an adjournment was asked for, and the arbitrators never met again on the case.

Since that time the claimant and the greater number, if not all, of the then arbitrators have died.

It is, however, quite likely that the rights of the water power lessees will ere long assume a shape that a decision in relation to it can no longer be delayed.

The lease, as above stated, is dated 1851. Since that time the canal has been nearly tripled in sectional area, on at least the upper part of the summit level. It will therefore be necessary to ascertain whether the representatives of the former water power lessees, who were to have water for not less than 20 runs of millstones, and who had in 1861 sub-leased water equal to 83 runs, are still to have all the surplus water disposable at Lock No. 3, even after the sectional area of the canal has been made about double what it was in 1861, or nearly triple

what it was at the time when the lease was granted. Besides, the river pier was (1856) carried up stream to an extent that had the effect of raising permanently the water level, immediately above the guard lock, fully six inches, which still further increased the means of furnishing a supply.

In this connection it may be stated that the bottom of the upper reach was originally made with a declivity of one inch and five-sixteenths, as sufficient to give a full supply of water, and, at the same time, afford an uniform depth at its lower end as well as at the guard lock.

But the demand for water, to supply mill power from this reach and the two other reaches below it, was such that frequently when there was 9 feet 10 inches water on the lower mitre sill of the guard lock, the depth at Côte St. Paul Lock, the lower end of the upper reach, was only at its proper height (9 feet on the breast wall).

This, after making a suitable allowance for cross currents, made a surface declivity of ten and five-sixteenths inches, or equal to two and three-eighths inches per mile, or a current of one and one-eleventh miles per hour, and at some of the bridges it was found to be considerably more.

This strong current rendered it necessary for ascending vessels to have much additional towage power, and those descending lost steerage way, consequently there was frequently experienced so much difficulty in large vessels passing each other as often led to delays, and sometimes serious collisions.

At periods of low water in the river this supply could not be maintained, so that the mills had to be restricted, and the interests of navigation, at such times, it is to be feared were not always kept fully in view.

A lively recollection of these occurrences, no doubt, operated forcibly on those directly interested in vessels, as well as those connected with water power, and induced some of them to be strongly in favor of two canals, one ostensibly for large vessels, the other for small craft; but, in reality, one for navigation and another for water power.

But, whatever the object of these recommendations may have been, the solicitude of those making them could scarcely be expected to equal that of those interested, or desirous of being interested, in the lands in that vicinity, who appear to have had notions of a peculiar nature on this subject.

The long stretch of low ground on the north-east side of the present canal, known as the Lachine Swamp, led to the impression that a new channel could be made through it to better advantage than to enlarge the old one, which

induced some of a speculative turn of mind to invest at high rates in this property, although it had previously been considered of comparatively little value.

An authority having been granted for the necessary expenditure to construct a canal adapted to the enlarged scale of navigation (various lines for which had been previously surveyed), it became necessary to examine all the projected schemes carefully before a plan could be recommended for adoption.

On looking closely into matters connected with the Lachine Swamp line, the material, for a stretch of fully half a mile, was found to be muck from 5 to 9 feet in depth below the bottom line for the canal, all of which would have to be removed in order to form banks, without the slightest probability of finding the bottom of a retentive nature, inasmuch as it seemed not unlikely to be similar to the adjoining rock, full of seams and fissures such as would allow the canal water to escape.

There would be, therefore, not only great difficulty in getting through this water-charged swamp, but strong probability, in both the low and high parts of it, of leakage, and, consequently, damages to adjoining property.

It was also found that no suitable material, for a water-tight bank, could be obtained within a long distance of the place where it would be required.

On considering all the known circumstances, it was then, as now, believed that less risk would be incurred, and less outlay required, to enlarge the old canal than to form a new line through the low ground above mentioned.

The advantages of a large channel over a small one are well known to those acquainted with the movements of vessels, still it may be stated, as done on a former occasion, that recognized authorities represent, no doubt correctly, that resistance rapidly increases as the channel diminishes below about six and a half times the sectional area of that of the vessel passing through it, thus leading to the conclusion that the interests of navigation would be better consulted by applying the money towards the enlargement of the old canal, rather than to attempt making a new and very doubtful line.

The question that next presented itself in connection with the enlargement, was the entrance at Lachine, for the reason that the greater part of the present inlet was known to have been formed through a rock shoal for its full width, about 100 feet, and to a depth adapted to the passage of vessels of 9 feet draught at what was at the time understood to be low water. But the depth in reality at such times is scarcely sufficient to enable vessels to enter freely, even after the height of the water has been permanently increased fully six inches, by an extension upwards of the outer or river pier.

It will therefore be quite evident that this channel could not be enlarged to the width required, or sunk to the depth necessary at low water, without serious interference with the navigation.

As the latter could not consistently be entertained, various lines and places were examined with a view of enabling a decision to be arrived at, viz :—Leishman's Point, near the place where the Lachine railway wharf is situated, the landward side of the present basin at Lachine, and along the south-easterly or river side of the channel now in use.

After looking into the matter fully, the latter place was believed to possess many advantages and have comparatively few objections. It was therefore recommended as the best place that could be selected in that vicinity, especially as the works connected with its formation and construction could all be carried out without interruption to the traffic of the present canal.

The design, when carried out, will embrace an area of 48 acres, 20 of which will be basin space, and a channel-way of 200 feet in width will occupy about 28 acres. A large part of this space is naturally of the full depth required for the enlarged scale of navigation.

To obtain this additional harbor accommodation, no obtrusion on private property was necessary except for a short distance at the place where the new basin and canal connect.

These and other known matters, bearing directly on the question of the enlarged scale of navigation authorized, led to the conclusion that the object could be best accomplished by the selection of an entrance at the place above mentioned, and that the reach between the guard lock and Côte St. Paul should be made to a mean width of 150 feet, or to a sectional area of 1,950 square feet, which is about one-fifth greater than that authorized for the other canals.

From Côte St. Paul Lock downward to Wellington Street Bridge, the water-way, it was thought, should be increased to a mean width of 200 feet, and protected by side walls, constructed in the manner subsequently described.

For many years, the basin and wharf accommodation at Montreal was found to be quite inadequate to the requirements, on the early evidences of which the Government purchased, in 1852, about fifty acres of land from the Seminary of St. Sulpice for these and other purposes connected with the canal; but no permanent use was made of the land until the works of enlargement were undertaken.

It was also long found that delays were frequent at the two lower locks on the canal, occasioned at times by locking up vessels from the harbor and their early return without proceeding further west than some place in the Montreal basin.

This, amongst other matters, shewed the necessity of having another outlet, a fact that was often urged by those interested in vessel property, and occasionally referred to in the annual reports of the Department.

These various questions were kept in view when considering the question of enlargement, and the plans believed to be best adapted to all the circumstances and the requirements were recommended.

The line of the old canal, continued downwards, had long been looked upon as the best position and direction for the new entrance channel, there being in reality no other eligible place in that locality where a sufficient space could be obtained for vessels to pass each other between the locks.

In connection with the foregoing general remarks it may be stated that new locks have been constructed in every case nearly opposite the old ones, all of which are 270 feet long between the gates and 45 feet wide, and, together with all permanent structures on the line, are arranged for a depth of 14 feet on the lock sills, except the walls of Wellington Basin and the two lower locks and basin between them, which are placed at a depth corresponding to 18 feet on the lock sills.

For the purpose of enabling the works to be placed under contract and the subsequent carrying of the operations, the line was divided into eleven sections, for which tenders were at different times invited by public advertisement, and the works awarded in the usual way to the lowest tender.

The late John G. Sippell, Esq., superintending engineer, an energetic, competent and reliable officer, was placed in immediate charge, who, with two resident assistants, H. K. Joslin at the Montreal end of the line, and H. H. Killaly at Lachine, conducted the general business in a judicious and creditable manner.

Under the superintending engineer and his assistants, inspectors of masonry and of carpenters' work were employed during the time such services were required, and in special cases other arrangements were made for the satisfactory carrying out of the undertaking.

Section No. 1.

This section extends from the line of 19 feet of water, at low stages of the river in the Harbor of Montreal, upwards along the line of the original entrance to a sufficient distance above the upper wings of the second lock, to enable the piers for the Mill Street road bridge and regulating weir on the east side of the basin to be built.

It includes the formation of a new outlet or entrance into the Harbor of Montreal, on the south-east or river side of the one leading to or from the old canal; the construction of two lift locks, placed at a depth to have 18 feet at low water on the sills for the gates; the formation of a basin between these locks, 540 feet long and 240 feet wide at the upper end of the first lock, and 280 feet wide at the lower end of the second lock; forming horizontal and vertical recesses for a guard gate at the upper end of the second lock, and extending the upper wings so as to form piers and abutments for a swing bridge to carry the traffic of Mill Street road, and construct a regulating weir, with a raceway from it, in connection with the south-east dock wall above the bridge.

The upper gate quoins of the new entrance lock are nearly opposite those of the old outlet lock, and at that place the centre lines of the old and new channels are 180 feet apart, and at the heads of the second locks the respective centre lines are 100 feet apart.

The piers at the outlet are of crib work, on which a continuous superstructure of pine timber has been built, and well secured throughout, and the whole filled with ballast.

All the masonry of the locks, dock walls, bridge abutments and weir, consists of an approved class of limestone, prepared for the respective places, and laid throughout in hydraulic cement mortar, as provided for in the contract. (See Appendix No. 35.)

In excavating the foundation pit for the outlet lock, a good deal of difficulty was experienced from water leaking in in different ways, especially through the bank adjoining the old canal, at a place where such an occurrence was least expected.

The bottom of the pit was also found to be so soft that it became necessary to drive piles for a considerable distance along the outer sides of the pit, as well as along in line of the face sides of the walls, to keep the material in place, and be able to remove from nine to twelve inches of the top of it in order to substitute a stratum of concrete to form a bearing surface for the foundation timbers.

There was also much difficulty in getting the necessary sheet piles at the mitre sill platforms put in properly, from the great quantities of water that found its way in through gravel beds, underlying at places the soft material on top.

But the troubles were still more perplexing towards the lower end of the pit, where it was, at one time, thought an entire foundation of bearing piles would have to be formed, which, at that time, late in September, could not have been done that season.

On further consideration, it was, however, decided to drive a transverse range of piles a few feet below the line of the mitre sill platform, and another a short distance below the lower end of the lock, and to remove, for a depth of 2½ feet, the whole of the soft material between them, then level up the entire space to the height required for the floor timbers with concrete.

This plan was successfully carried out, hence there is good reason to believe that as the soft material has been fully confined, the contemplated object may be looked upon as practically accomplished.

Before undertaking this work, it was apprehended that there would be an unusual quantity of water, and other difficulties to contend with when preparing the foundation of this lock; but it is only fair to state that, although the leakage as a whole did not exceed what was expected, it entered the pit in a different way, and the material of the actual bottom turned out to be of a nature unlike what was anticipated.

At the same time, reasonable doubts may be entertained whether the interests of the works were consulted—in whatever way those of the contractors may have been benefitted—by conveying the water from the upper parts of the section to the lower end of the outlet lock before removing it from the pit.

It should, however, be borne in mind that the time for proceeding with the works on the lower end of this section was limited by the high water of the river to about four or five months in the year, and that the pumps and other necessary equipments had all to be removed before winter set in and replaced when operations were recommenced the following season.

The masonry of the lower lock was completed in October, 1878; but in May, following, it was found that the ice jam during the preceding winter or spring had displaced a large part of the coping, all of which had to be taken up, relaid and secured by vertical rods passed down through it into the wall below.

The upper or second lock on this section occupies the place where the three combined locks at the outlet of the original canal were situated, the foundation of the lower one of which was nearly on the same level as that of the new structure; but the bottom of the centre lock was about eight feet higher. The side lines of the new and original locks are nearly parallel to each other; the new north wall is 10 feet thick, for which an off-set was made. For the most part, the old side wall was left undisturbed, and, where necessary, it was properly under-pinned and otherwise secured.

On excavating the lower part of the foundation of this lock to the depth required for the floor timbers, the bottom for the entire width and fully two-thirds of its length was found to be of a soft nature, such as rendered it necessary to remove the whole surface material for a depth of from 6 to 21 inches, and to substitute for it a stratum of concrete of sufficient depth to form an uniform bearing for the foundation timbers. Concrete was also used as a bottom covering for some distance above and below the lock, in the sheet pile trenches, and between the timbers in the chamber, etc.

It may here be stated that to get the north wall of the basin, between the first and the second locks, in one continuous straight line, it was necessary to remove a considerable extent of old crib work that had been built in connection with the former entrance channel.

This is mentioned, not so much from its actual importance, as from the fact that it forms one of the items of a claim made by the contractors.

The piers at the entrance to Montreal Harbor, the two lift locks, the intermediate basin and dock walls, bridge piers, regulating weir and raceway from it to the river, the macadamized roads on both sides of the lower basin, the water-tables between the new locks and basins, the pitched stone facing to the banks on the south or river side, are completed, as well as all the other works described in Appendix No. 35.

Section No. 2.

In this section is comprised all the works connected with the excavation or dredging necessary to make, what is called, Basin No. 2 an uniform depth of four feet below the top of the lower mitre sill of the third lock, from a point near Wellington Street Bridge to about the head of the second lock; enlarging the basin by the removal of a triangular point of land that projected north of the road between Wellington Street Bridge and the weir at Tate's Dock; the deepening of this entire space, and forming a channel way 19 feet in depth

from the head of the second lock up to Wellington Basin. The whole of the material excavated to be disposed of without passing through any of the canal locks, or in any way obstructing or interfering with the passage of vessels.

In it is also included the formation of Wellington Basin, which is 1,250 feet long, 225 feet wide, and has a depth of 19 feet below the surface level of the adjoining part of the canal; construction of dock walls of masonry laid in hydraulic cement mortar on three of its sides, wharves, sewer for drainage, etc. (See Appendix No. 36.)

All the works comprised in the contract for this section are completed, with the exception of levelling the bottom at several places in the deep channel through Basin No. 2.

The contractors, when proceeding with the enlargement at the south-west end of this basin—in September, 1876—being desirous of doing all the work they could before the close of the season, diminished the bank so much as led to a breach, which resulted in filling Wellington Basin earlier than anticipated.

Attention is drawn to this from the fact of the contractors having presented a claim for injury done to their plant, detention and expenses caused by the flooding of the basin, although it appears to have been occasioned by themselves after they had been not only cautioned, but directed not to weaken the bank. (See Appendix No. 42.)

Sections Nos. 1 and 2 were originally let separately. Section No. 1 was awarded to A. P. Macdonald & Co., and a contract made with them in September 1873. Section No. 2 was awarded to Messrs. Lemay & Bowie, and a contract made with them in October, 1873; but the latter soon afterwards disposed of their interest to their neighbor contractors, A. P. Macdonald & Co., who ultimately found it desirable to invite assistance to enable them to carry out the undertaking.

On application to the Department, and after full explanations were given, the original agreements for both sections were cancelled, and a new contract made in March, 1875, with James Worthington & Co., at the same rates and prices, respectively, as in the first contracts.

Under this firm the works have been carried on until they are nearly, if not altogether, completed.

The payments made upon both sections up to the 31st December, 1879, amount in the aggregate to the sum of $1,036,800.

Section No. 3.

The works comprised in this section were of a varied and extensive nature, the execution of some of which was attended with unusual difficulty, requiring all the practical knowledge and energy of the persons upon whom devolved the actual carrying out of the undertaking. The original contractors at the outset sub-let the whole, a matter, it is to be hoped, that was of advantage to themselves, as it was not found to be of any known loss to the works or parties connected with them.

It extends from a short distance below Wellington Street Bridge to about 700 feet above the 3rd or St. Gabriel Lock, a distance of fully three-quarters of a mile.

Within these limits are embraced the construction of piers and abutments for a new swing bridge at Wellington Street; the enlargement of the channel to a mean width of 200 feet; building dock walls along the sides of it; the bottom to be sunk to 13 feet and the side walls laid at 15½ feet below the regular water line; the construction of a new lift lock on the north side of the old one at St. Gabriel, forming a regulating weir and raceway between the new structure and mill property on the north side; building bridge piers and abutments; taking down part of the walls of the old lock and rebuilding it with new stone, etc. (See Appendix No. 38.)

All the works included in the contract are completed with the exception of the upper part of the masonry connected with the swing bridge at St. Gabriel Lock, the stones for which have been provided.

In order to enable the operations connected with the enlargement on this and other parts of the line to be carried on, the water was drawn out of the canal, as fully as circumstances would permit, in December, 1876, and not again let in until about the 4th May, 1877; it was again emptied in December, 1877, and the supply cut off until 4th May, 1878, and in the winter of 1878–79, it was, for the third time, emptied to allow the bottoming through the rock cut, and some of the principal structures to be completed.

During the three winters that the water was kept out of the canal, the works were urged forward as expeditiously as possible; some of them doubtless to less advantage than if the roads and weather had been favorable.

It is true that the line of the enlargement, at the lower end of the section, admitted of excavating an independent trench to the required depth, and of

building a part of the dock walls in summer, but the quantity was comparatively small and the circumstances rather unfavorable ; at all other places, the masonry was what may be called winter work, except that connected with the new lock and regulating weir.

It may here be stated that the foundations of the dock walls are sunk 15½ feet below the level of the reach in which they are situated, so that the channel, which is now 13 feet deep, can be made of a depth corresponding to 14 feet on the mitre sills of the 3rd and 4th locks when required.

This section being wholly in the City of Montreal, where only a small extent of canal land, at two different places, could be used for spoil ground, one on the south side of the canal near the lower end of the section, the other on the north side near the middle of it. Under the circumstances it was decided to allow the contractors to make the best arrangements they could, with the adjoining proprietors, to raise the low ground in the vicinity ; otherwise to deposit all the material at the places above mentioned, by raising the banks to such a height as may be necessary to enable this to be done.

Traffic on the canal having been unusually slack for a portion of the time that the works were in progress, the contractors were allowed to take part of the dredged material through the lower locks in scows, which is understood to have been carried some distance below the city and dumped in deep water ; a part was also taken to Lachine. It is estimated that about two-fifths of the material dredged was deposited in the river, one-fifth of the excavation was placed on private property, and the balance deposited on the spoil ground set apart for that purpose.

On taking down the upper part of the side walls of the 3rd or St. Gabriel Lock, they were found to be in a very bad condition, the vertical joints generally, and in some cases the horizontal joints, were nearly empty. The stones were shattered, apparently by frost, especially at and for a short distance above the water line of the lower reach.

The apron below the lower gates was completely undermined, and the foundations of the wings were beginning to be scoured out, so that, to render the whole secure, a great deal more work had to be done than anticipated.

The lower north wing of the lock had to be taken down to the foundation, especially all that part of it that projected beyond the rear side line ; and below the range of the apron or lower part of the floor, the seat for the east side of the

centre retaining wall had to be sunk to a depth corresponding to that of the new structure.

With a view of enabling the new lock to be constructed at a favorable season, a concrete wall, three feet thick, was formed along the back or north side of the old lock, understood to have been commenced at the depth of 5 feet below the bottom of that structure, and carried up to at least eighteen inches over the line between the old and new parts of the side wall.

The precautions taken to guard against leakage were not, however, for a time quite successful, as the water from the lock found its way either under, through or over the concrete to an extent that, for a time, was quite alarming. It was, however, stopped sufficiently to enable the works to be carried on advantageously after driving a range of piles along in rear of part of the north side of the wall, and filling the intermediate space with concrete; but to get this done the line of the new structure had to be moved a few feet farther to the north than originally intended.

As the new lock occupies the place where the regulating weir for the old canal stood, the raceways to and from it had to be closed before the lock pit could be laid dry.

This rendered the construction of a temporary weir and raceway on the south side of the canal necessary, the works connected with which, being of a peculiar nature, were not embraced in the contract, but were entrusted to the management of the canal superintendent, who accomplished the object in an economical and satisfactory manner.

Authority having been granted for the widening, deepening and improvement of the water-way on the north-west side of the island above St. Gabriel Lock, arrangements were made in January, 1879, to have the work done, which, there is every reason to believe, will be found of great service to the locality.

In 1871, the Grand Trunk Railway Company constructed a bridge over the Lachine Canal, in line of Wellington Street, Montreal, under certain conditions as to its being adapted to both railway and ordinary traffic. It was built according to a design submitted by the Company, and was a large, heavy structure, that required a steam engine to move it. In the autumn of 1878, it was reported by the officers of both the Railway Company and those of the Department that the bridge was then in a condition that it required such repairs as to practically mean re-building (it had then been in use for about 8 years).

The necessity of so large an expenditure to secure the efficiency of the old structure, together with the known inconvenience arising from the use of it, and the general dissatisfaction that reasonably prevailed in relation to it, led to the decision of at once constructing an independent bridge for ordinary traffic. This decision was immediately communicated to the General Manager of the Grand Trunk Railway, in order that the Company might prepare for building an independent structure of the kind required for their own special service.

After some discussion on the subject of the bridge, and the liability of the Company and of this Department in connection therewith, it was ultimately decided that the Company should remove the bridge then in use, and build a new structure solely for railway service, this Department to build the piers and abutments for both bridges, an arrangement that was agreed to and acted upon in good faith by J. Hickson, Esq., General Manager of the Grand Trunk Railway Company.

At this place, as in other cases where there are separate or detached bridges, the water-way of the canal is in four divisions, the two centre ones of which are intended to be used for the navigable channels, the one on the northerly side for westward-bound vessels, and that on the southerly side for those eastward bound.

The seat, pivot and rest piers, as well as the abutments of the bridges for both the street traffic and that for the railway, are of block stone masonry with longitudinal openings through the pivot and rest piers. The intermediate longitudinal spaces between the respective ranges of piers are of crib work, through which a continuous water-way is formed of the same sectional area as that in the masonry, with lateral openings for the purpose of diminishing the head of water raised by vessels when passing.

Arrangements have also been made for the protection of the different structures, as provided for in the specification for the works on the section. (See Appendix No. 38).

In order to carry out the plan of having two bridges at the Wellington Street crossing of the canal, it became necessary to widen the street on the west side, and this could only be done by filling up a small basin adjoining the canal, commonly called the Wood Basin, it being used only for the purpose of landing firewood.

This basin, although small, was at one time quite an advantage to the neighborhood, but of late years it was found to be rather a nuisance than otherwise.

It was formed when the first enlargement of the canal was in progress, on land purchased for that purpose, and, although there is a street between the basin and private property, some parties who own land bounded by the street claim damages for the basin having been filled up.

These claims have been strongly urged on several occasions; they were ultimately referred to the law officers of the crown, who, on looking into the matter, state that no liability attaches to the Government for filling up the basin or for alleged damages to the claimants' property.

Forming a greater extent of basin and wharfage, at the lower terminus of this canal, being one of the considerations connected with the enlargement, it is believed proper to recapitulate what has been done within the past few years in these respects, viz:—

Between the 1st and 2nd locks there is.....	600	lineal feet	wharfage
In Wellington Basin.....	2,625	"	"
Basin or slips above Wellington Street crossing.	2,960	"	"
North and south sides of channel between Wellington Bridge and St. Gabriel Lock..	3,600	"	"
Making.....	9,785	"	"

The old wharfage between the 1st lock and Wellington Street, taken as a whole, amounts to about 5,000 lineal feet.

Hence, there is now 14,785 lineal feet of available wharfage between the outlet of the canal and the 3rd or St. Gabriel Lock.

As previously stated, all the works embraced in the contract are looked upon as completed in a creditable and satisfactory manner, and the detailed final estimate of them is now in course of preparation.

The payments made to Messrs. McNamee, Gaherty & Fréchette, the contractors for this section, up to the 31st December, 1879, amount in the aggregate to $604,409.17.

In this connection it may be stated that tenders were invited for furnishing the materials, preparing and fitting up the superstructure of the road bridge at Wellington Street crossing, and the work was awarded in February, 1879, and a contract subsequently entered into at certain fixed rates.

The structure is formed of such a combination of wood and iron as, experience has led to the belief, would best meet the requirements, necessary for a bridge exposed to all the risks, of a line of navigation used by a large class of vessels.

At all those places liable to decay, iron, of such shapes, and scantling, as best adapted to the circumstances, have been freely used, and wood at such places as can be protected from the influence of the weather, and readily renewed in case of accident, and throughout, every precaution has been adopted to provide for strength and durability. (See Appendix No. 37.)

The works were commenced in February, 1879, and the whole completed, and the bridge in satisfactory working order by the 5th day of May following, when a settlement in full was made with the contractor, John McDougall, which in the aggregate amounted to the sum of $9,987.71.

The construction of a bridge above the 2nd lock at what is generally called the Mill Street crossing of the canal, was advertised, and the works also awarded in February, 1879, and shortly afterwards a contract was entered into at fixed rates.

This bridge is of similar construction to the one above mentioned, and is fully described in Appendix No. 37. It was completed and in satisfactory working order by the 5th May last, when, shortly afterwards, a settlement in full was made with the contractor, Mr. W. P. Bartley, to whom the sum of $7,927 was paid.

The superstructures of both these bridges were built under the general superintendence of Mr. T. B. Townsend, the gentleman who matured the principal parts of the design.

Section No. 4.

The works on this section are completed, and the contractors, Messrs. Whitney & Doty, have been settled with in full. The whole sum paid to them amounts to $255,379.14.

This part of the enlargement extended, from near the head of the island above St. Gabriel Lock, westward 3,800 feet, to a short distance above the Grand Trunk Railway swing bridge.

It comprised the enlargement of the channel to a mean width of 200 feet, and lowering the bottom to an uniform depth of 13 feet below the water line, or to 4 feet below the top of the lower mitre sill of the old lock at Côte St. Paul; facing the inside of the banks with pitched stone, laid at right angles to the face;

the removal of the piers and abutments of two swing bridges, and the construc tion of others adapted to the respective positions and circumstances; alteration to the culvert formerly constructed under the canal for passing one set of th mains for the Montreal Water Works, etc. (See Appendix No. 39.)

When this section was let, the lands on both sides of the canal were gene rally private property, and as it was considered undesirable to purchase land at high price merely for the purpose of using it for spoil ground, it was stated i the specification, for the information of parties tendering, that not more tha one-third part of the excavated material could be advantageously placed on spoi ground adjoining the canal. The other two-thirds of the quantity would hav to be placed from four to sixteen hundred feet back from the line of the canal within a distance of one mile and a half from the lower end of the section.

Tenders were also received, subject to the condition of the contractor finding spoil ground, at his own cost and expense, for all the excavated material othe than that required to make up the banks of the canal to the necessary width and height.

This system was found to be a complete check to discussions about over haul, bad roads, or alleged unforeseen matters of that kind. The contractors were paid the prices fixed by themselves for material deposited on canal property, and in like manner when they found the spoil ground themselves.

The excavation for the widening of the channel was chiefly on the south east side of the line, where, during summer, a continuous independent cut was formed for fully one-half the length of the section, and to the full depth required for the foundation of the wall ; but in the course of making it, a deep muck and peat bed was met with, which led to a good deal of expense, trouble and anxiety, before the bank over, or rather through it was looked upon as safe. There was also considerable expense incurred in preparing a seat for that part of the side wall, through the muck bed, as a large part of the muck had to be removed and the place filled with stone before the wall could be started.

The works above mentioned, with the exception of dredging operations and the providing of materials, were all that could be done during the summer season to carry out this part of the undertaking. All the other parts of the works had to be carried on in the winter and the early spring months, when they could be got at, after the supply was shut off at the entrance and the water at other places withdrawn.

It was well known that the canal could not be laid altogether dry, and that at times water was liable to get into it in various ways, hence provision was made for forming a dam at both ends of the section, one at the upper end to prevent water passing on to, or coming from Section No. 5, and one at the lower end to guard against water getting on to, or coming from Section No. 3. The construction, maintenance and removal of these dams was to be embraced in the lump sum for unwatering the works.

This provision was made in the specifications for all the sections above the third lock, but the contractors, instead of acting up to it, made arrangements amongst themselves to put in low dams between the sections, thus assuming the risk of having their works flooded by the neglect or otherwise of those on other parts of the line.

The result of this arrangement was especially unfortunate for the contractors on Section No. 4, as it led to a large outlay for pumping, besides the stoppage of their works for a considerable time at what was, otherwise, a favorable season for conducting the operations advantageously.

In order to obtain the necessary width of water-way, as well as to get the navigable channels at the Grand Trunk Railway bridge in the right position, it was necessary to remove the old abutments and pier built by the Railway Company, and to construct others in their stead. To enable this to be done, involved the necessity of forming a line of trestle work, on which the railway traffic could pass during the time that the removal of the old and construction of the new works were in progress. For this, together with girders over the landward or side openings of the enlarged water-way, the Grand Trunk Railway Company was paid, on a special arrangement, the sum of $8,000.

This work had to be done hurriedly under very unfavorable circumstances, the roads at the time being in the worst possible condition. It is, however, satisfactory to be able to state that the acting contractor, Mr. L. Whitney, was quite equal to the emergency, and, throughout, gave his undivided attention to the various works, evincing, in all cases, much practical knowledge in his arrangements, and energy in carrying out the undertaking.

Section No. 5.

This section is situated between the Grand Trunk Railway swing bridge and the lower factories at Côte St. Paul, and is altogether about 4,200 feet in length. The contract for it comprises the enlargement of the channel to a mean width of 200 feet, and lowering the bottom to a depth of thirteen feet, or to

4 feet below the top of the mitre sill of the old lock at Côte St. Paul; building protection walls of pitched stone, laid at right angles to the face, on the inside line of the banks, and constructing of masonry an inverted syphon culvert to carry the water of the River St. Pierre through under the canal. (See Appendix No. 40.)

The greater part of the remarks, relative to spoil ground in connection with Section No. 4, apply equally to Section No. 5, that is to say, at the time of letting the works on this part of the enlargement, the lands on both sides of the canal were generally private property, it was therefore considered undesirable to purchase land at a high rate solely for the purpose of using it as spoil ground.

Tenders were therefore received on the basis of the contractor finding spoil ground for all the excavated material not required for making up the banks of the canal to the necessary height and width.

Offers were also invited on the understanding that the Department would find deposit ground for all the material excavated, one-fourth of which was to be placed within a distance of from 30 to 130 feet from the water line of the enlarged canal, and three-fourths of the entire quantity placed at a distance of from 400 to 1,600 feet from the water line, but otherwise within the limits of the section.

In the specification for this part of the line, as well as for those parts on both sides of it, provision is made for the construction of a dam at each end of the section—one at the upper end to prevent water passing on to, or coming from Section No. 6, and one at the lower end to guard against water passing on to, or coming from Section No. 4.

The formation of these dams was therefore no doubt included in the bulk sum tendered for unwatering the respective works, consequently any other arrangements made by the contractors was on their own responsibility.

At the lower end of the section, the water-way was widened chiefly on the south side, and at the upper end the widening was wholly on the north side. When proceeding with the works at the latter place, there was found an extensive bed of muck, overlying marl, under which was soft clay.

The muck and marl was removed, in short stretches at a time, to a depth of from three to four feet below canal bottom, and the place filled in with material most likely to form a proper seat for the bank and side wall. This part of the work was done in summer, and, although not free from difficulty, it was then done to better advantage than it could have been done at any other season.

The construction of a stone culvert with three arched openings, to carry the ter of the River St. Pierre through under the canal, on this section was a work anded with more than ordinary trouble; but the contractors used every effort accomplish the contemplated object, and ultimately succeeded.

To enable this to be done, they felt called upon to build a shed over the ater part of the trunk, so that the work could be carried on advantageously winter. This course made certain what, otherwise, would have been a little ubtful, besides it insured a better class of work. It seems, therefore only fair at at least part of the outlay necessary for that purpose should be refunded to e contractors when a final settlement is made.

This culvert has now a sectional area of fully 78 square feet, which is conderably more than the old one, and the outlet of it has an inclination of two rizontal to one vertical. These, together with the straightening and idening of the old channel of the river a few years ago, will doubtless ve a tendency to diminish, to some extent, the height of the water during ow floods in the future, especially when there is a free discharge for the water the south-east side.

It may here be stated that the class of wall adopted, for the facing of the nks on the whole of the reach between the 3rd and 4th locks, admits of forming arves, when required, on both sides of the channel. The inclination of the e will allow a vessel of the full draught to be within 5 feet of the water line, d by far the greater number of vessels need not be more than half that distance t from the top line of the wall.

There is a probability that, for lumber and bulky articles of that kind arves in that vicinity may yet be found serviceable; provision has, therefore, en made that, when required, they can be leased to parties desirous of obtaining ch accommodation. There would be little or no objection to this, so far as navition is concerned, as it is quite probable that, ere long, nearly all vessels passg through that part of the canal will use steam tugs; consequently, paths for w horses will cease to be a part of the system.

All the works embraced in the contract for this section have been completed, d a detailed estimate of them prepared, but a final settlement has not yet en made.

The contractor, A. Charlebois, has been paid up to the 31st December, 1879, e sum of $243,950.

Sections Nos. 6 and 7.

These two sections form one contract, which embraces the enlargement of about one mile and five-sixths of the channel; the construction of a new lift lock; taking down part of the old lock and rebuilding it; constructing piers and abutments for a new swing bridge; forming an inverted syphon culvert of masonry under the canal; making protection walls, etc. (See Appendix No. 41.)

There is about 700 feet of Section No. 6, below the old lock, which, like all other places on that reach, has been made of a mean width of 200 feet; all that part of Section No. 6 above the lock at Cote St. Paul, and the whole of Section No. 7, have been made of a mean width of 150 feet, and to a depth of four and one-fifth feet below the mitre sills of the old guard lock at Lachine.

The land in the vicinity being for the most part private property, the contractors had to provide, at their own cost and expense, nearly all the service ground they required for the purpose of placing and preparing materials, erection of sheds, storehouses and other purposes.

The widening of the channel for the whole length of Section No. 6, including the seat of the new lock and approaches to it, was on the north-east side of the old line; at the lower end of Section No. 7, it was also on the north-east side, but at other places the increased width for the most part was taken off the south-west side.

The spoil ground available for the excavated material, after making up the bank at the lower end of the section, was represented to be on low ground near the upper end of Section No. 7, and on the north-east side of the canal. Contractors were, however, to be allowed the privilege of raising the land of adjoining proprietors, provided satisfactory arrangements for that purpose could be made.

It was also stated in the specification, distributed before tenders were received, that "the principal part of the excavation on the section will be clay, but a part of it is of a hard nature; rock will, however be found below the lock at a height a little over the bottom line of the present canal, and at many places in the upper reach the surface of the rock is either at, or a little below the level of the present bottom, but it generally underlies a hard class of material composed of clay, gravel and boulder stones, firmly cemented together."

When deepening the channel above the lock, there was found a stretch, a few hundred feet in length, where boulder stones were large and numerous, for the removal of which the contractors have made a claim representing this part

of the work to be different from what is described in the specification, as well as different from what they expected.

Without attempting to discuss what the contractors' expectations were, or how they arrived at them, or their interpretation of the clause above quoted, it may be stated that the boulder stones were, no doubt, expensive to handle and remove; still they were quite convenient for wall building, a purpose to which many of them were applied.

The dredging operations for the deepening and enlargement of the channel, which were at first looked upon as rather unsuccessful, were ultimately found to answer a good purpose, and were therefore continued until near the completion of the undertaking.

When preparing the seat for the bank, on the north side of the canal and lock, part of the work was found to be of a troublesome nature, there being a stretch of black muck and marl, that had to be removed, for a depth of from ten to twelve feet below canal bottom, and suitable material selected and substituted for it, so as to form a firmer and less porous seat for the bank and side walls.

On taking down the upper part of the side walls of the old 4th lock, they were found to be in an equally bad condition as described for those of the 3rd lock; the vertical joints generally, and in many cases the horizontal joints, were nearly empty; many of the stones were in several pieces, especially the quoins and courses at and near the water line of the lower reach.

This was done and the wall rebuilt between the closing of navigation in December, 1876, and the opening of it the following spring, and, at the same time, a concrete wall, three feet thick, was carried up in rear of the north wall from a line five feet below the bottom of the old structure to eighteen inches over the line between the old and new parts of the side wall.

Notwithstanding the precautions taken to guard against leakage, there was much difficulty experienced in getting in the foundation of the new structure from an unexpected stream of water that found its way into the pit at and above the breast wall of the old lock.

The space between the old and new structures had to be increased beyond what was originally intended, and a heavy rubble wall built with a view of cutting off the water, all of which had the effect of lessening but not of stopping the leakage, which continued until the walls of the new lock were over the bottom of the upper reach.

The lower end of this lock is on a rock foundation, but the upper end of it is on clay, and throughout a bearing surface for the floor timbers and mitre sill platform was formed of concrete.

The whole of the works embraced in the contract for these sections (described in full in Appendix No. 41), have been completed, and the detailed final estimate for them is in course of preparation.

The contractors for them, Messrs. William Davis & Sons, have been paid up to the 31st December, 1879, the sum of $544,500.

It may here be stated that the report of H. K. Joslin, the resident assistant engineer on Sections Nos. 1, 2, 3, 4, 5, 6 and 7 is given in Appendix No. 42.

Section No. 8.

The contract for this part of the line comprised the enlargement of the channel for a distance of 7,543 feet to a mean width of 150 feet, and lowering the bottom to 13 feet below the water line, or to the depth of fully four and one-seventh feet below the top of the mitre sills of the old guard lock at Lachine; building side walls and otherwise protecting banks; forming towing path; grading berme banks; cutting side ditches; building culverts where required for drainage; forming a roadway along the south-east side of the canal, etc. (See Appendix No. 43.)

All the works above enumerated, and such others as are embraced in the contract and documents appended to it, are completed, and a detailed estimate of them is now in course of preparation.

It may here be stated that the contractors represent that at certain places on this section, where the bottom is clay, sand or material other than rock, they were called upon to excavate seats for the face protection of the banks, fully two feet lower than the general bottom, which caused them much additional expense for pumping; still they have been allowed nothing more than the ordinary rate for the quantity of material removed.

This statement, as to the depth of the seat for the protection walls, is quite likely to be correct, as it was no doubt sunk sufficiently low to admit of deepening the channel for the passage of vessels drawing fourteen feet of water, when required.

In the winter of 1878–79 a few prominent points were taken off the inside line of the north bank, for the purpose of widening and straightening the prism;

but, on letting in the water, leaks were found at some of the places where the face of the bank had been removed.

To stop this, a puddle wall nearly 1,500 feet long was formed in the bank, after a trench of the requisite depth and dimensions for it had been made. This part of the work had unavoidably to be done when the water in the canal was at its usual height, which necessitated a considerable outlay for pumping and otherwise unwatering the trench.

The contractors for this section, Messrs. O'Brien, Sullivan & Co., have been paid up to the 31st December, 1879, the sum of $316,100.

Section No. 9.

This was the first section placed under contract on the upper part of this canal, but, from various causes, it was amongst the last completed.

It is about 6,000 feet in length, including nearly all that part of the line known as the "rock cut."

The contract for it comprised the enlargement of the channel to a mean width of 150 feet, and to a depth of 4 feet below the top of the lower mitre sill of the old lock at Lachine; building side walls for the protection of the banks; forming towing path; grading berme banks; cutting side ditches; building culverts where required for drainage, etc. (See Appendix No. 44.)

Tenders for the works were invited by public advertisement, which were subsequently awarded to John Lyons and others, who entered into contract in January, 1876, and commenced the works under a firm called John Lyons & Co.

The rates at which they were let were then looked upon as exceedingly low, and the parties, it was feared, were deficient in both means and experience, and otherwise unsuited for carrying on such an undertaking.

They managed, however, to move along all the following summer, and until about the beginning of March, 1877, when the helpless derangement of their monetary affairs led to a complete stoppage of the operations. For about two months, at that time, nothing was done, although the canal was empty and the season unusually favorable for conducting such operations. It is, however, only fair to state that the contractors, towards the end of April, that year, did all they could to get that part of the canal ready for the opening of navigation.

Towards the autumn of 1877, it was represented that Messrs. Lyons & Co. had made arrangements with a practical person of good standing to carry to

completion the whole of the works. No objections were made nor intended to be made to that arrangement, so long as the works were expeditiously and satisfactorily executed.

The canal was again emptied in December of that year, after which the works under the new management were proceeded with in a manner that was little or no improvement on the former attempt, and about the middle of March 1878, John Phelan, with whom John Lyons & Co. had made the agreement, absconded, taking with him the bulk of the amount paid on the February estimate, and leaving the laborers unpaid.

It was then represented that a large number of men engaged in the practical execution of an important public work, for which they were only to be moderately remunerated, had been imposed upon by an unprincipled man, who had attempted to rob them and their families of the money they had honestly earned; while the greater number of them were poor and unable to assert their rights, even if their employer had left behind him any available property.

Many of the men were left so utterly destitute as to be unable to procure the ordinary necessaries of life; still, under all these depressing hardships, they conducted themselves in a quiet, peaceable and orderly manner.

There being then, in the hands of the Department, the amount payable for work done in March of that year (1878), together with part of the retained percentage, it was decided that these sums should be applied towards paying the laborers.

The aggregate amount paid at that time was $19,725.51.

The above sum, together with the amount paid directly to John Lyons & Co., on progress estimates, retained percentage, etc., up to the 31st December, 1879, amounts to $162,170.

It is, however, probable that a refund to the Receiver-General of $274.40 should be deducted from the above sum.

In the spring of 1878, the superintending engineer, the late John G. Sippell, was authorized to have all obstructions removed from the channel, and to take the course necessary to put this part of the line in a condition that navigation could be opened about the 1st of May.

At the same time, Mr. Sippell was requested to direct the superintendent of the canal, Mr. Conway, to give his attention to some of these matters, which he did in his usual energetic and active manner.

The expenditure for labor, tools, pumping, etc., for this purpose, amounted to the sum of $9,486.35.

The contractors were granted the most favorable consideration that could reasonably be extended towards them, without their evincing in any intelligible way their ability to go on with the undertaking. It was, therefore, decided in August, 1878, that new tenders should be invited by public advertisement, for the completion of the works, but they were not awarded until November of that year, when they were declared to Messrs. Williamson, Rodgers & Farrell, with whom a contract was shortly afterwards made for the execution and completion of the whole by the 26th day of April, 1879.

This firm at once set about providing the necessary equipment, and from the outset shewed, in a practical way, that they fully understood what they had to do, and further made it clear, in an energetic manner, that they fully intended to carry out the agreement into which they had entered. They doubtless labored under great disadvantage in getting the work so late in the season, still they succeeded in fully effecting the object of finishing all the under-water work in good time for the opening of navigation, and afterwards completing all the upper works in a creditable and satisfactory manner.

The detailed estimate of them is now in course of preparation, which will be unusually elaborate, from the fact of two different sets of contractors having gone over certain parts of the same work.

Messrs. Williamson, Rodgers & Farrell have been paid for the work done on this section up to the 31st December, 1879, the sum of $121,500.

Section No. 10.

The works on this section were awarded in January, 1876, and the same month a contract was entered into for their execution; they were completed in the summer of 1879, and a detailed estimate of them is now being prepared.

This part of the line is a new, and, for the most part, an independent cut situated on the south side of the old supply race, weir and old entrance lock at Lachine; it is fully 1,400 feet in length, and comprises all the works connected with the formation of a channel-way for that distance; the construction of a new entrance lock, with upper wings extended to form abutments for a swing bridge. Provision is also made in the bottom and side walls for a guard gate, which is to occupy a horizontal position when not in use. It also includes retaining and side walls, culverts, ditches, etc. (See Appendix No. 45.)

The whole of this section, except for a short distance at the lower end, was a thorough cut, the greater part of the material excavated from which was hauled and placed on the river side of the entrance, forming a bank fully 30 feet wide on top and nearly a mile in length, and to that extent giving full protection to the pier built alongside of the channel.

All the lower part of the excavation on the section is rock, but it was found to be generally unsound, and, for ordinary building purposes, of an inferior kind. It was, therefore, found necessary to lay a foundation of timber and otherwise form a floor for the chamber and other parts of the lock, on which the action of the water in filling or emptying it would be likely to have little or no injurious effect. As previously stated, all the works comprised in this contract are fully and satisfactorily completed, on account of which Messrs. Rodgers, Kelly & Co., the contractors, have been paid up to the 31st December, 1879, the sum of $269,200.

Section No. 11.

Under this heading is comprised all the works connected with the formation of the new upper entrance channel and basin, or harbor for the enlarged canal.

It is situated on the south-eastern or river side of the entrance to the old canal at Lachine, and is formed by means of a continuous line of pier work, about one mile and a sixth in length, alongside of which a channel 200 feet in width is intended to be sunk uniformly to the depth of 6 feet below the top of the mitre sills of the old lock. As stated in a preceding part of this paper, the water space that the carrying out of this plan renders available, is about *forty-eight acres area*, of which a channel-way 200 feet in width will occupy about *twenty-eight acres*, and *twenty acres* will be basin space. A considerable part of this space is naturally of the full depth required, but for a distance of about two-thirds of a mile outwards from the shore, the greater part of the channel has to be more or less deepened. To enable this to be done in the usual way, this part of the work has to be unwatered, for which preparations were made as the pier work progressed, and such other arrangements made as gives every reason to believe will enable the design to be fully carried out. (See Appendix No. 46.)

The whole of the double range of pier work on that part intended to be made water-tight, together with the cross dam, has been sunk, and the chamber between the two ranges of cribs, in both cases, has been filled with a good class material.

The 30 feet wide part of the crib work has also been sunk, the ice breaker at the upper end formed, and the superstructure has been put on the upper or outer 600 feet ; in short, the whole of the woodwork of the main line of the pier is in place except one closing crib.

The range of crib work alongside of the old pier has also been sunk, and the puddle chamber filled up as far as the service cross dam put in by the contractors, which is about mid-way between the main cross dam and the lower end of the section. It was, however, found that, at some places where the water is deep the ranges of narrow crib work are apt to spread from the weight of the puddle, even when the water between the dams is only partly withdrawn, especially where the inclination of the bottom is outwards from the line.

To prevent this, an arrangement was made with the contractors to have stones piled along by the bottom of the crib work at places where there were any indications of movement, which has, so far, been successful, and, as anticipated, will answer the purpose quite as well, if not better than to have made the crib work wider at these places.

When proceeding with the deepening of those parts of the channel opposite the upper entrance of the present canal, and at other places where the rock had to be loosened by under-water blasting, and subsequently removed by dredges, it was found that the strong oblique currents in that vicinity, when the preliminary examinations were made, had prevented the correct depths from being obtained, which has resulted in the quantity of material that had to be removed being greater than represented at the time the works were undertaken.

This part of the works, as well as the sinking of the piers, has been proceeded with in a moderately expeditious and satisfactory way, but the formation of the lower end of the channel is in a rather backward state.

The contractors seem to have been desirous of being thoroughly provided with pumping power, and, with that object in view, procured a pump unusually large of its kind, the working of which has not been so far a success, and on the 19th December last, it broke down, and brought all the other operations to a stand-still, which, up to the present time, 22nd March, have not been resumed, but preparations are now being made for a commencement at an early period.

Messrs. William Davis & Sons, the contractors for this part of the line, have been paid up to the 31st December, 1879, the sum of $472,900.

For the report of the Resident Assistant on this part of the line, see Appendix No. 47.

It has been represented, by parties interested in the ferry to Caughnawaga, that the works, at the new entrance to the canal, will have a tendency to prevent the ferry boat lying at or coming up to the Railway Wharf at Lachine during winter, and, therefore, the pier at that place should be extended, or some other course adopted, to be certain of securing an open crossing. This winter having been exceptionally mild, there has been no means of getting at the facts relating to the representations made. Instructions were, therefore, given to an officer who resides near the place to observe the action of the ice this spring, and otherwise collect such information as would be likely to enable an opinion to be formed as to what course could be judiciously recommended.

The respective amounts paid to the 31st December, 1879, to the contractors for the different sections of the works of enlargement, on each of the canals, having been already given, as supplied by Mr. Baine, the Chief Accountant, it is not considered necessary to repeat them.

LACHINE CANAL.

Contractors were paid up to the 31st December, 1879, the sum of	$4,064,481 68
Preparing Section No. 9 for opening of navigation in the spring of 1878	9,486 35
Paid for lands and other property, contingencies, etc	450,356 52
Land damages	3,562 23
Bridge works Grand Trunk Railway	8,000 00
Engineering and superintendence, etc	126,232 44
Works chargeable to enlargement 1878 and 1879	8,679 00
Contingencies, office rent, advertising, printing, etc	28,349 81
	$4,699,248 03

CORNWALL CANAL.

Contractors were paid up to the 31st December, 1879, the sum of	$391,456 82
Paid for lands and contingencies	7,518 13
Engineering, superintendence, etc	10,968 60
Contingencies, advertising, printing, etc	2,972 87
	$412,916 42

WELLAND CANAL.

Contractors were paid up to the 31st December, 1879, the sum of	$9,495,641 84
Paid for lands and contingencies	377,166 02
Paid for land damages	21,587 95
Engineering, superintendence, etc	285,903 03
Changing line of Welland Railway at Thorold	7,428 02
Contingencies, advertising, printing, etc	45,593 82
	$10,233,320 68

It is considered proper to state, before closing this report, that by the death, on the 26th September last, of Mr. John G. Sippell, this Department has lost the services of a valuable and highly efficient officer, who had honorably filled the position of Superintending Engineer of the Lachine, Beauharnois and Chambly Canals, etc., for fully 26 years.

On being made aware of the severe illness of Mr. Sippell, all the books and official documents were, on the 23rd of September last, placed in charge of Mr. Harrington, a trustworthy person, who has been for several years employed in the Lachine Canal Office.

All matters connected with the works of enlargement of the canal were continued, as heretofore, in the hands of the Resident Assistant Engineers, Mr. H. K. Joslin, at the Montreal end of the line, and Mr. H. H. Killaly, at Lachine; at the same time, the Superintendents of the different divisions of the canals were expected to attend to their respective duties as usual.

It is now, however, very desirable that the position of Superintending Engineer, rendered vacant by the death of Mr. Sippell, should be filled as soon as circumstances will admit, and that care should be taken to select an active, competent and reliable person, familiar with works of that class, as the duties are of a responsible, important and frequently of an onerous nature.

I have the honor to be, Sir,

Your obedient servant,

JOHN PAGE,

Chief Engineer of Canals.

APPENDIX No. 1.

WELLAND CANAL.

SPECIFICATION for the Enlargement and Deepening of PORT DALHOUSIE HARBOR, Construction of an ENTRANCE LOCK, Extension of Present Regulating Weir, &c., &c.; SECTION No. ONE.

The pier on the east side of the entrance to the harbor, is to be extended a distance of 300 feet farther into Lake Ontario, and the water-covered space on the eastern side of the present outlet-lock will be formed into a basin and channel for the enlarged canal—a new lift-lock with its upper wings extended to form bridge abutments, will also be constructed on the projecting point of land to the north of Andrews' Dry Dock—the present regulating weir will be increased 50 feet or more to the eastward, and ranges of guide piles or of crib-work, as may be subsequently determined, will be formed above the lock.

The structures, &c., will, for the most part, be placed in the positions indicated on the general plan exhibited—the centre line corresponding nearly with that marked out on the ground; but the Department of Public Works reserves to itself the right of changing the site or position of any or all of the structures, such a distance, and in such a direction as may be considered advantageous for effecting the objects contemplated.

These changes, it should be clearly and distinctly understood, may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items.

DEEPENING CHANNEL AND FORMING BASIN.

From the inside angle of the existing piers outwards, the channel, for a width of 170 feet, is to be sunk to an uniform depth of 4½ feet below the top of the mitre sill at the present outlet lock, or at all places to within 15 feet of the side piers. The slope on both sides of the channel to incline gradually toward the bottom side of the crib work.

From the extreme end of the present east pier in a continuous line with it outwards, and from the end of the west pier, on a line inclining north-westerly 100 feet from the range on that side, the entire space, out to deep water in the lake, is to be made of a depth of 4½ feet below the point above mentioned.

The site for the crib-work, which is to form the extension of the east pier, must also be made, at least, of a like depth. From the angle of the piers inwards, the depth will gradually diminish to near the lower end of the new lock, where it will be three and a half feet below the top of the mitre sill of the old or present outlet lock. The basin is to be made of the area represented on the plan, and a site for a range of pier work on each side of it must be formed one foot in depth below the general bottom, for a distance of about 900 feet north from the end of the new lock. A raceway from 120 to 150 feet in width, of the depth required, must also be formed in an oblique direction, from the basin up to the lower end of the regulating weir, in the position represented.

The bottom of the basin—channel between the piers—entrance, and all other parts of the dredged portions of the works, must be made as smooth and uniform as possible.

The material to be removed opposite and in the vicinity of the Welland Railway Elevator, and for some distance inside the line of the present piers, as well as outside of them, is found by borings made at intervals to be indurated clay and cemented gravel; at other places the material is chiefly clay, part of which is moderately hard and some of it soft. An approximate estimate of the quantities of indurated and ordinary clay will be found marked on the plan exhibited. Contractors must, however, clearly and distinctly understand that the estimate referred to is simply of a probable nature for which the Department of Public Works is not responsible, and that the respective quantities may be either greater or less than stated, without giving cause for any increase or diminution in the price for the item of dredging submitted in the tender. The price tendered per cubic yard must also embrace the removal of all sunken logs, the hulls of old scows, barges, or vessels, or whatever is to be found in the way of forming the basin to the full dimensions and depth described.

When the clay is moderately firm, or such as may be approved of for the purpose, it will be used for filling up part of the space in rear of the east or west docking, and when so used it must be levelled or trimmed off to such an inclination as directed.

All material dredged out of the basin, seats for pier work and docking, raceway and channel between the piers, at the entrance or elsewhere, other than required for the purposes above mentioned, must be taken out into the Lake in scows, or otherwise, and dumped outside the line of six fathoms water. The contractor may, however, in certain winds, be permitted to dump his scows to the eastward of the east pier, provided he keeps at least 500 feet from it and as close to the shore as possible, so as to be wholly within a line 200 feet south of the extreme end of the present west pier.

It is further to be fully and clearly understood, that all the dredging done towards deepening the entrance and channel between the piers, as well as for the extension of the east pier, deepening and forming the basin and for the seats of the respective lines of docking, raceway, &c., will be measured, computed and paid for in the *solid*. For this purpose accurate soundings will be taken over the whole area to be dredged, before the works are commenced, and referred to a fixed and permanent bench-mark.

Duplicate copies of the sections made from these soundings will be prepared, one of which will be placed on record in the office of the Department of Public Works and the other remain in the office of the resident engineer. From these documents, after it has been fully ascertained that the different places are of the respective depths contemplated, the dredging done, and for which the contractor is entitled to be paid, will be computed.

EXCAVATION.

The material excavated from the place to be occupied by the lock, or extension of the weir, as well as that taken from the cutting for a road up the bank on the east side, where of a suitable kind, must be hauled and placed wherever it may be required to

make up embarkments connected with the structures, or to fill up in rear of the respective lines of docking or low ground between the present lock and basin, within a distance of 1,000 feet from the cutting.

The cost of handling, hauling and depositing of the material at the place and in the manner directed, as well as the grading and formation of road and all other works of that kind which may be required, must be embraced in the price tendered for excavation.

In cutting, as well as in embankment, the side slopes, unless otherwise directed, will be made two horizontal to one vertical, but whatever the angle may be the face must be trimmed off neatly and present throughout an uniform surface.

The contractor, when proceeding with the works, must invariably be guided by the levels given and lines marked out by the engineer or officer in charge.

When forming embankments in rear of the lock and weir or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally; well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely "Earth" and "Rock;" the former to embrace all kinds of materials found in the cuttings, except absolutely connected "Quarry Rock" and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal, forming embankments, grading towing path, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price, per cubic yard, for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

EXTENSION OF EAST PIER.

The east pier is to be carried 300 feet farther into the lake and there terminate in a square 60 × 60 feet, inside of which, to the end of the present pier, the width will be 30 feet, and the whole will be formed of crib work up to about the surface of low water.

CRIB WORK—to be of the full width above stated and in lengths of at least 30 feet. The sides and ends to be of timbers not less than 11 inches square, straight, sound and full on the edges, carried up vertically to within two feet of the water surface, where a batter of one in twelve is to be commenced on both the front and rear sides.

FRAMING.—The outer timbers of the cribs are to be framed so as to leave a space of 2 inches between the different courses, and at the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends.

At each corner in every course, a rag bolt 12 inches long and five-eighths ($\frac{5}{8}$) of an inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 × 11 inches at both ends, and of the full length of the outside width of the different cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be midway between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides, so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie, at the joint between the courses immediately below it, a block 2″ × 11″ × 11 inches is to be inserted to give an uniform bearing, and a rag bolt $2\frac{1}{2}$ feet long, seven-eighths ($\frac{7}{8}$) of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it, and 4 inches into the head of the next cross tie.

LONGITUDINAL TIES.—In all the cribs, longitudinal ties, 10 inches thick, are to be framed into, and dovetailed between the alternate tiers of end timbers, have blocks under them, and be secured by bolts of similar dimensions and in like manner as described for the transverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails, 2 inches diameter and 16 inches long.

In the cribs forming the terminations of the pier, there must be longitudinal ties in every course placed alternately 10 feet and 20 feet from the face side.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say :—one at or near each angle, and another in the centre ; making in all six vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spikes, five-eighths ($\frac{5}{8}$) of an inch diameter, two driven through each plank into each of the lowest side pieces, and one at every crossing of a side timber from the floor upwards. They may be put on in lengths of from 8 to 10 feet or more, but they must be so arranged that the upper lengths in all cases shall reach down at least 2 feet lower than the top of the plank of the same range below.

BALLAST FLOORS—to consist of flatted timbers, 10 inches in thickness, and of the full length of the width of the respective cribs. They are to be laid transversely from 5 to 6 inches apart, and rest on either the first or second course of side timbers, as may be directed, and to which every alternate piece is to be fastened at each end by a bolt three-fourths ($\frac{3}{4}$) of an inch diameter and 18 inches long. There are to be two longitudinal timbers dovetailed into and secured to the end pieces at the proper height, to form bearings for the floor.

The cribs, from the botttom upwards to low water line, may be formed either of pine, cedar, ash, tamarac, or elm timber ; but whatever kind is used, it must be straight and of good quality, free from shakes, sapwood, unsound knots, or other defects.

Before a crib is put together, the contractor must take correct close soundings over the place it is to occupy when sunk, and where such inequalities occur as cannot be removed, the bottom of the crib must be adapted to them, so that when placed in its berth the sides and ends shall be plumb, and the whole form a line corresponding to that marked out by the officer in charge.

Immediately after a crib has been moored in the right position, the contractor, if so directed, must lay a platform of plank over it of sufficient size and strength to carry enough stone to sink it, and when thus sunk, and ascertained to be on the proper line and place, the crib is to be filled with an approved class of moderate-sized stone, closely packed.

The square head at the outer end, may, up to low water, consist of four cribs, each 30 x 30 feet.

When the whole of the cribs shall have been sunk, well filled with stone, and settled in their respective berths, the sides must be brought to an uniform height at low water line, either by cutting down and removing the top timbers, or using suitable levelling pieces as may be required.

THE SUPERSTRUCTURE—is then to be commenced, and carried up with a batter of one in twelve to the height of other parts of the pier, or to such other height as directed. The face timbers to be of pine 12 inches square, generally not less than 40 feet long, or of such other lengths as will break joint properly over and upon the different cribs. They are to be scarfed at the ends where they connect; the scarf to be square at heel and toe and have a lap of 18 inches, with a block underneath, and be secured with a bolt 18 inches long and three-quarters ($\frac{3}{4}$) of an inch diameter. The timber must be counter-hewn, if required, and laid so as to leave a space of $1\frac{1}{2}$ inches between the courses.

TRANSVERSE TIES—of flatted pine timber, of a size to square 10 x 11 inches at both ends, and of a sufficient length to extend across the pier, are to be placed not more than 10 feet apart in every course of the superstructure. They are to be dovetailed, and let into the side pieces over and under them—have a block $1\frac{1}{2}$" x 12" x 12 inches inserted between the two courses under the head of each, and be secured by means of rag bolts, seven-eighths ($\frac{7}{8}$) of an inch in diameter, in a similar manner to those described for the cribs.

LONGITUDINAL TIMBERS—of flatted pine are to be carried up between the alternate courses of like dimensions; be framed, notched into cross-ties, and secured generally as those described for the cribs.

BINDING PIECES—of 4" x 10 inches pine plank, are to be placed vertically inside for the entire height, and fastened with spikes, five-eighths ($\frac{5}{8}$) of an inch diameter and 10 inches long—one at every crossing of a face timber. They are to be not more than 14 feet apart, and are in every case to form continuations of the respective ranges underneath.

STRINGERS.—To form bearings for the top covering, five stringers, each 7" x 10 inches of pine, are to be laid the whole length of the extension, secured to the cross-ties, and placed at a like height as the side timbers.

The whole interior of the superstructure must be filled with a good class of stone, carried up as the timber work proceeds, and care taken to pack them well at and between the ties, as well as to have the top part properly levelled.

TOP COVERING—to be of good quality, of 3-inch pine plank, of sufficient length to pass over the side timbers and meet on the centre stringer. They are to be laid crosswise, one inch apart, and be fastened at the ends and at every crossing of a stringer with 6-inch pressed spikes. The covering is to be further secured by chamfered cap pieces of white oak or rock elm, 10"x6 inches,—one range along each side and another in the centre over the joinings of the plank. The cap pieces are to be fastened with rag bolts three-fourths ($\frac{3}{4}$) of an inch diameter and 18 inches long.

If directed, waling pieces, 12 x 10 inches, of white oak or rock elm, chamfered on the edges, are to be placed along the channel side of both piers, within 5 feet of the top, or at such other height as may be afterwards decided. They are to be fastened with rag bolts one and one-eighth ($\frac{1}{8}$) inch diameter and 20 inches long, made with good upset heads, and driven 8 feet apart, or such distance as may be required.

The head or outer portion of the *east* pier, for a space of about 30 feet square in the centre of the rear part of the east side, is to be carried up 6 feet higher than the adjoining superstructure, and be built and secured in like manner as described for the other portions of the work; except that there are to be inside binders on the end from the bottom upwards, as well as on the sides, and the inner end of the raised part is to be stepped off, or otherwise made to form an easy means of access; and the top covering is to be 5 inches thick.

MOORING POSTS—of white oak or rock elm, 10 feet long and 16 inches diameter, are to be placed in the pier, from 40 to 50 feet apart, or at such other distances as may be subsequently determined. They must be properly dressed, covered on top with a cast-iron cap piece, notched at bottom to receive cross pieces 5 feet long, be fastened to the cross-ties with screw-bolts of $1\frac{1}{4}$ inch round iron, and be otherwise secured as directed, placed so as to stand 18 inches over the top covering, and have the ballast around them well packed.

The sides of all the superstructure must be hewn down neatly, and everything done that is necessary (although not herein particularly mentioned) to place the whole in a finished and satisfactory condition.

DOCKING.—In the position shown on the general plan there will be a line of docking constructed, on each side of the basin. On the east side it will be carried downwards from the tail of the lock until a connection is formed with the docking in front of the Welland Railway property. That on the west side will extend a short distance north of the triangular point of the bank, on east side of the present outlet lock, as indicated on plan. In the latter there will be seven oblique openings varying from 12 to 18 feet in width to admit of the discharge from the regulating weir passing freely. The docking to be 18 feet in width, formed of crib-work in lengths of 30 feet or more up to low water line, over which the superstructure will be continuous.

The sides and ends of the cribs are to be of timber 11 inches square. Ties of flatted timber of a size to square 10 x 10 inches, and the floor timbers are to be 9 inches thick.

The cribs are to be framed, dovetailed and secured by means of bolts and binding pieces; have blocks under the heads of the ties, and be of a like class of work as described for those in the extension of the east pier, except that no longitudinal stringers will be used.

Those which are to form the sides and divisions between the openings through the west docking are to be framed of an oblique shape, and if directed must be made of close work *i.e.* each side and end timber is to have a bearing of at least two-thirds of its length

on the timber immediately underneath, and at no place is the opening between . em to exceed one-fourth of an inch. For a distance of 150 feet below the lock, on both sides, the pier is also to be of close work.

The bottoms of the cribs are to be adapted to the respective places they are to occupy when in position, and when sinking them a loaded platform on the top is to be used so that they can be arranged correctly on the line and at the place required. They are then to be filled with an approved class of stone, care being taken, wherever practicable, to pack the ballast closely around and between the ties.

After the tops of the cribs have been brought to an uniform height at low-water line, the superstructure is then to be commenced and carried up of pine timber (both sides and ties) framed, dovetailed, fastened with bolts, have blocks under the heads of the ties, and be secured with binding pieces as described for the upper part of the extension of the east pier, except that there will be no longitudinal stringers and the top is not to be planked.

The stone ballast with which the whole of the spaces under, over and between the ties are to be closely and compactly filled, must, however, be levelled on top to an uniform height, and if so directed is then to be covered with a layer from 6 to 8 inches deep of gravel.

A cap piece of white oak or rock elm 10 x 6 inches, chamfered, to be put on the top face timber for the whole length of the dock and fastened by rag bolts three-quarters ($\frac{3}{4}$) of an inch diameter and fifteen inches long.

The openings through the docking on the side of the basin are to be bridged over by five or more ranges of stringers 12 x 12 inches, supported by corbels projecting over the piers, and covered on top with three-inch pine plank well spiked. The north end of this range of docking is to be made to correspond with a line which will run along the east side of the entrance to the present lock.

For 150 feet below the new lock on both sides of the basin, after the crib-work, which forms a continuation of the line of docking, has been well filled in with stone, sufficiently settled and levelled up at about one foot below low water line, a platform chiefly of 12 x 12 inches pine timber will be laid along the top front side of each stretch.

This platform in each case will be five feet wide at the outer end and seven feet near the lock. The timbers of which it is formed must be in lengths of 30 feet and upwards —laid throughout so as to break joint at least five feet with those along side. The front range to be fourteen inches deep and bevelled on top if required, and all of them must be fastened to the cross-ties as directed. Mooring-posts of like dimensions and similarly prepared as described for the pier extension, are to be placed 50 feet apart in the bank in the rear of the docking, or otherwise arrangod as may be subsequently determined. They are to have near their lower ends cross-pieces notched into them, and be secured in other respects as may be directed, and when placed, stand 18 inches over the top line of the docking.

ENTRANCE LOCK—to be 270 feet in length between the gate quoins, 45 feet in width between the side walls at the mean surface level of Lake Ontario, and the bottom of it must be so arranged that the top of the mitre sills shall be three feet lower than those in the present outlet lock.

It will be constructed of dressed stone masonry laid in hydraulic cement mortar, placed on a foundation prepared as herein described, and the upper wings of it will be extended to form bearings for a swing bridge to carry the travel of the road between St. Catharines and Port Dalhousie.

The pit and foundation for the structures to be made of suitable dimensions to admit the side walls, wings, &c., and to correspond with such lines as will be marked out by the officer in charge, and to such slopes as may be required for the stability of the banks during the building operations.

The bottom must throughout be trimmed fair, smooth and level at a proper height to give an uniform bearing to the foundation timbers or base of the walls.

All the material excavated from the foundation and lock pit must be hauled and placed to make up the banks in rear of the docking on either side of the basin or be deposited elsewhere, in embankment or spoil, in such a manner as may be directed.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length, to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed, or with concrete, and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers before being laid must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as the other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn, and well jointed with a plane so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through, and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &C.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must, in all cases, be made of the best materials for that purpose which can be obtained in that vicinity; cut, mixed, prepared, and laid as directed by the officer in charge.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

The five foundation timbers, to which the sheet piles are to be fastened, must each be of sufficient length to reach from rear to rear of the walls of the recesses.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inches diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned, and secured in the manner shown on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 3 inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons, and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvass, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one and a half inches (1½″) diameter, have upset heads, and be well ragged at the point.

MASONRY.—The side walls of the new lock will be commenced at the level of 3½ feet below the top of the mitre sills of the present outlet lock, and will be carried up to 2 feet over the surface water level of the upper adjoining reach. The chamber walls are to be 10½ feet wide at bottom, with counterforts in rear 6 feet long in line of wall, and 3 feet projection, placed not more than 12 feet apart—the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping; and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound, and durable stones; those which form the face-work must be free from drys, seams, or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and color and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths (3-16ths) of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

CUT STONE—to be neatly dressed and boucharded; made square, bevelled, or otherwise, suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than two and three feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face, and $4\frac{1}{2}$ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{4}$ times their height; and in all cases the tail of a header must have a width of $\frac{2}{3}$ the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least $4\frac{1}{2}$ feet face and $5\frac{1}{2}$ feet depth of bed; the latter $5\frac{1}{2}$ feet face and $4\frac{1}{2}$ feet bed. The headers are to checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also $4\frac{1}{2}$ by $5\frac{1}{2}$ feet, and $5\frac{1}{2}$ by $4\frac{1}{2}$ feet, laid alternately out-bond and in-bond, bevelled as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain-wells in the positions indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock walls, are to be made at the angles and widths to permit the play of the chains; and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face, and 4 feet depth of bed placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

BACKING—to consist generally of well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedged-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls, except in the recesses where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain-wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top and two feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed one-fourth (¼) of an inch.

A dowel, 4 inches long, of 1½ inch iron, to be inserted in every joint 15 inches back from the face, and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be 7 feet wide at bottom, 3 feet on top, built of coursed masonry, and covered with suitable coping.

BRIDGE ABUTMENTS—as represented on plan, are to be built at the head of the lock in continuation of the side walls. They are to be of a like class of masonry as described for the chamber walls of the lock; carried up to the height shown on a detailed plan to be furnished—recessed, curved, and otherwise adapted for the toe as well as for the turntable on which the bridge is to move.

The coping stones to be at least 15 inches in depth, and of large dimensions, those under the turntable to form a circle to support the trackway for the rollers. The pivot stone to be not less than 5 feet square and 2 feet depth of led.

If the foundation is uniform and good, the walls are to be placed on a foundation of timber and plank, and have a range of sheet piles along the front side, sunk to such a depth as may be directed. In case the material is of a soft and yielding nature, it must be removed for such a depth as will admit of laying eighteen inches or more of concrete under the timbers. If, however, the bottom is very soft, the contractors must furnish and drive such a number of piles, of the dimensions required, as may be necessary to form a proper bearing for the walls, as well as to provide and drive a continuous range of well jointed close sheet piles at the toe of the masonry on each side. In the latter case the tops of the piles are to be cut off at an uniform height and ranges of sills secured to them, either cross or longitudinal, or both, as may be required, and concrete used for at least a foot below the top of the piles as well as between the sills, or any other arrangements made that circumstances may require.

CONCRETE—where used, must consist of an approved quality of stone broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement, and clean sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar, made of the best hydraulic cement, mixed with clean large grained sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings, provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the directions and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half (1½) of clean sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them ; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls, or any portion of them, are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls ; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED,—in rear of the lock walls, to be three feet in width, carried the entire height ; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered properly, cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at the back of the walls, made up in the manner already described, are to be 25 feet in width, and have a declivity of six inches outwards from the lock.

The superstructure of the swing bridge, also the fixtures and machinery required for working it, as well as the lock gates, will be made a separate contract ; but all the masonry required is to be done by the contractor for the lock.

RUBBLE WALLS,—forming the extension of the wings at the foot of the lock, will be carried up on the platform laid on the top of the crib work for their reception. They are to be built of large sized, well-shaped stones of a durable nature, properly bonded over and with each other, and laid throughout in hydraulic cement mortar.

At the upper end, the walls are to be carried the same height as the lock coping, and at the lower end be a like height as the docking : they are to be built to such lines as will form a suitable approach to the lock, and the face of the stones is to be hammered or scabbled to such batters or lines as may be required to adapt them to the position they are to occupy in the work,—coping to be of approved sound stone, three feet wide and twelve inches thick, roughly dressed and jointed, and at least 4 feet long in line of wall.

REGULATING WEIR.—The eastern side wall of the present structure is to be taken down and the length of the breast increased 50 feet or more towards the east. A foundation for the extension is to be formed at a level two feet lower than the bottom of the present weir, if circumstances admit.

The material excavated from the pit is to be used for forming banks where required, and must be hauled and placed in the manner previously described.

The bottom of the pit must be trimmed to a level and uniform surface to receive the foundation timbers, which are to be of pine, 12 inches square, laid 12 inches apart, and so as to rest on mud-sills placed within the line of the side walls, and on the bottom throughout their entire length. The space between the timber to be filled with a good description of puddle, well beaten down, or with concrete; floor to be of 3-inch pine plank, laid so as to break joint every 3 feet in width of planking, and be well fastened with white oak treenails, 9 inches long and 1½ inches in diameter; two in each end of a plank, and one on alternate sides at every crossing of a timber. Below the breast wall and between the wings, a second course of plank, 2 inches in thickness, is to be laid and fastened as may be directed.

There are to be three ranges of sheet piles across the foundation; one above and another below the breast wall, and the third at the lower end of the wings; they are all to be of like dimensions, placed and secured as stated for those in the lock foundations.

MASONRY—Walls are to be built in the positions, and be of the respective dimensions represented on the general plan; throughout they must consist of sound and durable stones, free from seams and other defects, laid in full mortar, on their natural beds.

The wings are to be of "Rock Work," carried up to a batter of 1 in 12, face 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course, dressed and laid so that the beds and end joints shall not exceed three-eighths (⅜) of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work laid to a batter of about 4 inches to the foot rise. Great care must be taken to form a good connection between the old and new work.

There are to be six sluice-ways through this wall, each four feet wide and four feet high, the sides of which are to be dressed smooth—sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

BREAST WALL COPING—to be four feet wide on top, increasing in width downwards to the batter of the wall, the lower bed and joints must be kept full throughout, and the top dressed fair and so as to have a declivity of one inch towards the up-stream side.

A pier is to be carried up above the breast wall to form a bearing for a bridge; it is to be 5½ feet wide at bottom—batter on both sides so as to be four feet wide at top, and built in courses corresponding in height to those of the breast wall, and of such a width of bed that two stones will make up the thickness of the pier, and have headers not more than 9 feet apart, passing entirely through the wall.

The coping to be dressed on top, and of the full width of the wall. Offsets on the different courses of the lower wings to be made from 5 feet over the level of the lower reach, as represented on plan. Wing coping to be at least 12 inches high, 3½ feet wide, with beds and joints kept full throughout, and top neatly boucharded.

In addition to a range of piles to be placed in line of the breast wall, a counterfort of masonry, 4 feet thick, and at least 7 feet in length, will be carried up in rear of the east wing-wall to the height of the water level of the upper reach.

BACKING—To be of a like class of stone, and laid in like manner as described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared as stated for other portions of the works.

A puddle bed 3 feet in width is to be carried up in rear of the side or wing walls, to the full height of the water level of the upper reach. The material used for this purpose, as well as for the puddle between the foundation timbers, and for the sheet pile trenches, must be of the best and most suitable kind that can be obtained on the section or in the vicinity of the work.

SLUICE GATES—to be built of the best quality of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to 3½ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron, seven-eighths (⅞) of an inch in diameter, passing through the gate; and to have straps of wrought iron 3 inches wide and three-eighths (⅜) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush, and fastened, at distances not more than 6 inches apart, with rivets ½ an inch in diameter countersunk into the straps. The top plates are to be 2¾ inches deep, and those at the bottom 6½ inches deep, each to have a flange from the centre outwards on opposite sides.

The gates are to revolve on the centre, on pivots working into the bottom plates of the gates, and on the top of each a disc of steel or hard brass is to be placed, and have a brass collar and lining. The pivots are to be 3½ inches diameter, connected with plates 9 inches square and 2 inches thick, let into the sills of the sluice-way, and secured to them by fox-bolts.

The gates are to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key-bolts to the piers and lintels of the sluice-way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed.

The turning rods are to be of wrought iron, 3 inches diameter, of sufficient length to pass through the gates and stand six inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates, and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected with racks on the platform, made so as to secure the gate in the position required.

GUIDE RANGES—are to be constructed at the south end of the lock in the position shown on plan. They may be either formed of crib-work of a like class as described for the extension of the pier and docking, or they may be of piles, or of piles and crib-work combined.

In case the bottom is of an unusually soft nature, it is probable that cribs may be dispensed with, and floating guide ranges formed, and kept in place by piles along each side—piles to be braced transversely and obliquely at the height suited to the circumstances. The rates tendered for piles to be applicable in either case, and the rates tendered for docking to apply in case pier work is built.

In the execution of the works generally, but especially that portion of them connected with the enlargement of the regulating weir, great care must be taken to guard against interrupting or in any way interfering with the operations of the present canal. Before the existing roadway is obstructed or in any way disturbed, the contractor must provide at his own cost and expense, satisfactory means for the public travel to pass freely at this place, either by the construction of a temporary bridge, or some other way by which the general travel will be best accommodated. It is further to be clearly and distinctly understood that he (the contractor) shall be held strictly and legally liable and responsible for keeping the crossing in such a condition that it can be safely used during the whole time

the work is in progress of construction ; and that he will remove at his own cost, when directed, any bridge or other temporary means of crossing that may have been formed.

The bulk sum tendered for the removal of "Andrews' Dry Dock" must include the cost of taking down and clearing away the side wall, pulling or taking out piles, cutting out and clearing bottom ; removal of gates and everything connected with the dock, and placing all the materials moved at such points as may be directed.

The bulk sum tendered for unwatering the works must embrace the cost of constructing all coffer-dams required to keep out the water of Lake Ontario, as well as that of the present canal, and to guard against leakage, springs or surface drainage, together with the expense of pumping, bailing, removing ice and snow, and every contingency directly or indirectly connected with unwatering the lock and weir pits, or any other portion of the works, during the progress of the operations, and up to the full completion of the whole undertaking ; and the satisfactory removal of all coffer-dams and other temporary constructions.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction ; but detailed working drawings, arranged, modified and adapted to the lock and weir foundation, and for all such other parts of the structure as may be required, will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, &C.—The contractor must provide at his own cost and expense all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be required for canal purposes by the Department of Public Works. He must also provide, furnish and deliver at his own cost all necessary materials, and procure all plant, tools, implements, derricks, machinery and labour, and everything necessary for the satisfactory execution and completion of the work, as contemplated in this specification.

All materials must be of the best class of their respective kinds ; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

Tenders will not be considered, unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stock, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the work embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the first day of April, 1877.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 8TH MAY, 1875.

APPENDIX No. 2.

WELLAND CANAL.

SPECIFICATION for the Construction of a Regulating Weir, Sluice Gates, Roadway Bridge, etc., at PORT DALHOUSIE.

The structures are to be placed to the westward of the new outlet lock, in the respective positions indicated on the general plan, and must be executed of the class of materials, and in the manner, herein described :—

The breast of the weir is to be at right angles to the line of the lock walls, and its upper or southern side 73 feet north of the range of the upper gate quoins ; the top face line of the east side wall of the weir is to be about 83 feet from the face of the west wall of the lock. The distance between the side walls will be about 91⅛ feet, the breast wall to be 13 feet thick at bottom and 4 feet at top, strengthened by three piers arranged so as to divide the distance into four equal spaces, and in each of these bays there are to be three sluice-ways, each 4 feet square, the sills of which are to be 18 feet below the surface level of the upper reach, or 20 feet below the top of the coping of the new lock.

It is to be clearly and distinctly understood that, if the nature of the foundation, improvement of the line, or any other circumstances, render it necessary to change either the line, position or dimensions of the weir, or the line of the bridge, the Department of Railways and Canals reserves to itself the right of making all such changes as may be required, either by diminishing the size of the weir or altering the site, position or direction of all or any of the structures, as may be considered advantageous for the better carrying out of the objects contemplated.

These changes may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

EXCAVATION.—The pit for the weir is to be excavated to about 112 feet in width and 44 feet in length, and sunk to the depth of 21¼ feet below the surface level of the upper reach, or 23¼ feet below the top of the coping of the new lock, or deeper if required.

The bottom must be trimmed off smooth and level, so as to give a fair and uniform bearing for the foundation timbers. Tracks for subsills are to cut where required, and trenches for sheet piles sunk 5 feet in depth at the places indicated on the plan, or hereinafter described, or at such other places as may be pointed out by the officer in charge.

The materials excavated from the pit are to be deposited along the outer westerly and south-westerly sides of the present bank or roadway, between the old storehouse opposite the flour mill and a point intersecting a line extended across the tail of the weir; all of which must be placed in a satisfactory manner, so as to increase the width of the roadway.

When the weir and side walls shall have been completed, all that part of the present roadway or dam above and opposite the weir must be removed to the full depth of 15 feet below the top of the coping of the lift lock, part of the upper portion of which may be used to make up the bank in rear of the side walls of the weir and the retaining or side walls above and below it; and that part of the material that has to be removed by dredging must be taken to such places in the pond, within one mile and a half of the weir, as may be directed.

After the completion of weir and side walls, the lower dam must also be removed to lines marked out for that purpose, and to a depth of within two feet of the lower mitre sill of the lift lock; all the materials from which must be taken out into Lake Ontario in scows, and dumped outside the line of six fathoms of water.

All the excavation required to be done for the extension or retaining walls, above and below the weir, must be done by the contractor at the time directed; and the material, from both the east and west sides, must be hauled and placed so as to make up and increase the width of the roadway on its west and south-westerly sides, as described for the excavation from the weir pit.

In estimating the excavation of the weir pit and the retaining walls, a slope of one to one will be allowed, and in consideration of which the contractor must assume the full and entire responsibility of removing, at his own cost and expense, any slides of the side material that may take place during the progress of the works.

The cost of handling, hauling and depositing of the material at the places, and in the manner directed, including the grading and formation of roads, forming embankments, and all other works that may be required, as well as any material which it may be found necessary to take from borrowing pits or other places (within a distance of 500 feet) and placing the same in embankment, must all be embraced in the price tendered for excavation.

It should further be fully and clearly understood that all the dredging done for the removal of the dams at present above and below the weir pit, and making the waterways to the respective depths stated, will be measured, computed and paid for in the *solid*. For this purpose accurate levels and soundings will be taken over the whole area to be dredged, before the works are commenced, with reference to a fixed and permanent bench-mark, and from these, together with soundings and measurements afterwards made, the quantities of dredging done will be estimated.

All the stones of the old weir which have to be removed from the site of the new one, will be measured and paid for as ordinary excavation, and such portions of them as may be suitable can be used for backing the new work.

FOUNDATION OF WEIR—to be formed of pine timber 12 inches square, laid from 10 to 12 inches apart, in ranges corresponding to the line of the breast wall and sheet piles. The entire width of the foundation to be made up of two and three lengths of timber alternately, that is to say, the butt-joint in one range is to be immediately under the centre pier, and in the adjoining range the butt-joints are to be under the middle of the two intermediate piers.

All the timbers must be carefully counterhewn on their upper and lower sides, or sawn to the proper thickness, and laid so as to have an uniform bearing throughout their entire length, and present a fair surface for the plank. They are to rest on subsills placed under the side walls and piers, and the spaces between and at the ends of them, as well as around the subsills, must be carefully filled with concrete, prepared as subsequently described, well rammed into all the openings and made to a full fair surface to receive the floor plank.

In case of any inequalities in the surface of the bottom or site, the soft parts must be cut into level benches to such a depth and extent as may be required, otherwise the whole area of the bottom must be lowered one foot or more, as may be directed, and a stratum of concrete, of the proper depth, laid to form a fair bearing surface for the floor timbers.

TRENCHES, ETC.—For the reception of sheet-piles, trenches are to be excavated at the places represented on the plan, that is to say, one at each end of the weir walls, one at the upper side of the breast wall, and at such other place or places as may be directed. They are to be sunk 5 feet below the bottom of the foundation timbers, and made 2 feet in width at bottom and 2½ feet at top. One side of each trench must be cut down plumb, and as smooth as possible, so as to afford an even bearing to the piles for their entire depth; if necessary, the piles must be bedded in cement mortar at the time they are put in place. After the piles are in position the trenches must be well filled with concrete, to the height of the adjoining ground.

In rear of the side walls of the weir, puddle beds, 5 feet in width, are to be extended out opposite the breast wall to the old or solid bank, and carried up to one foot over the water surface of the upper level.

PUDDLE.—At all places where puddle is herein stated, or may be subsequently directed, to be used in the work, it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render it impervious to water.

SHEET PILES,—to consist of 3-inch pine plank, placed vertically, and generally 6 feet long; they are to be jointed with a plane, and have the edge of each plank chamfered on the side next the trench. When in position they are to be fastened to the foundation timbers with two 7-inch spikes through the top of each plank. The course in line with the upper side of the breast wall must extend at least three feet beyond the rear line of the counterforts on the east and west sides, and be continued outwards to the bank, up to high-water mark. All the other courses must extend out fully to the rear line of the respective walls.

FLOORING.—The bottom and entire spaces to be occupied by the side walls, breast wall and piers of the weir are to be covered with a course of 3-inch pine flooring, all the planks of which must be carefully jointed with a plane, and when being laid must be driven up by means of dogs and wedges to close joints, and fastened

to the foundation timbers with white oak or rock elm treenails, 9 inches long and 1¼ inches diameter, two at each end of a plank and one at every crossing of a timber, on alternate sides. Every three feet in width of plank to break joint at least four feet.

On the lower side of the breast wall, between the piers and between the side walls and piers, the lower floor must be dubbed to an uniform surface, and a second floor of 2-inch pine plank laid so as to break joint over the planks underneath, and be fastened with 7-inch pressed spikes.

MASONRY.—The walls of the weir are to be commenced on the top of the first course of plank, or 22 feet below the level of the coping of the new lock. They are to be placed in the position, and be of the respective dimensions, herein stated, or shown on the plan and sections. They must be built throughout of gray limestone, of a sound and durable class, free from seams and other defects, in courses which may vary from 10 to 24 inches, and laid, in all cases, on their natural beds, in properly prepared hydraulic cement mortar. The faces of the walls are, for the most part, to be of "rock work," but the face stones forming the upper side of the breast wall and sluice-ways must be dressed fair and smooth.

SIDE WALLS—to be 9½ feet thick at bottom, from the south or upper end to 4 feet below the lower face-line of the breast wall, thence they are to diminish to 6 feet at the north end. The face to have a batter of one in twenty-four, and the back to be carried up plumb to within four feet of the top, then batter to the rear line of the coping.

The face stones must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 10 feet from centre to centre. The upper and lower beds of both "headers and stretchers" must be dressed parallel for at least two-thirds the depth of the bed, and the end kept full for at least 9 inches back from the face; the face may be left rough, but no projection on it can be allowed to exceed two inches. The dressing to be such that the horizontal and vertical joints between the stones, when in place, shall not exceed three-eighths (⅜) of an inch. Checks for stop logs are to be cut in the faces of the piers and side walls, both above and below the breast wall, in the position shown on the plan and in the manner subsequently described.

BREAST WALL—To be 13 feet thick at bottom, 4 feet at top, and 19½ feet high; to be built of stone 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep and not more than 9 feet apart. All of them must be dressed so that the horizontal and vertical joints shall not exceed one fourth (¼) of an inch. The wall is to be carried up and bonded into the piers and side walls, the courses of all of which must either be of a like height or be checked for that purpose.

The upper side of this wall, in the different bays between the piers and between them and the side walls, must be dressed and carried up plumb, from an offset on the sill course, and have checks or recesses formed in it to receive the plank packing for the frame-work of the sluices; the lower side to be "rock-faced" work, laid to a batter of about 5 inches to the foot rise.

In the breast wall there are to be, as before stated, 12 sluice-ways—three in each bay—each of them 4 feet wide and 4 feet high; the top, bottom and sides of which are to be dressed smooth.

The sills for them must, throughout, be 2 feet in depth of course, and in each case the stones must be 6 feet in length, and of such a width as to make up the full thickness of the wall in five pieces. They must all be of the full dimensions, and be dressed so as to lay to one-fourth ($\frac{1}{4}$) of an inch joints, both horizontally and vertically, for their full length and depth and for the entire thickness of the wall, and the upper sides of all of them must be dressed to a fair smooth surface.

In the upper edges of all of the upper sills, checks for the sluice-gates are to be cut out, 5 inches deep at 7 inches back from the face, and 9 inches deep at the face-line.

The piers between the sluice-ways, in all the four divisions of the water-way, are to be two feet in width, and must be made up of stones the full thickness and of such a depth of course as to make up the full height (4 feet) in, at most, three courses. They must be neatly dressed on both faces, and, when laid, be bonded over and with each other at least one foot.

The lintels must be at least 20 inches depth of course, 6 feet in length and of such a width as to make up the whole thickness of the wall in four pieces. All of them must be of the full dimensions and be dressed so as to lay to one-fourth ($\frac{1}{4}$) of an inch joints, both horizontally and vertically, and the lower sides of all of them must be dressed to a fair smooth surface.

The faces of the lintels on the up-stream side, for 10 inches from their lower side, and for their full height and for one foot at both ends of them, are to be sunk $3\frac{1}{4}$ inches, and the ends of the piers, between the sluice-ways, as well as those adjoining the side and division walls, are to stand back to the same line. The recesses over them are also to be formed to the height of $4\frac{1}{4}$ feet above the upper line of the sluice-ways, thus forming recesses of the depth stated ($3\frac{1}{4}''$) to receive the plank packing for the frame-work, etc., of the sluice-gates.

The centre and intermediate piers, or the division piers, are to extend the whole length of the foundation above and below the breast wall. They are to be 5 feet $9\frac{1}{2}$ inches thick at bottom and batter on both sides at the rate of five-eighths ($\frac{5}{8}$) of an inch to the foot rise to $3\frac{1}{2}$ feet in width at top. From the upper end to three feet below the lower line of the breast wall, the piers are to be carried to the same height as the side walls, and the lower ends of them to be made to a batter of about 7 inches to the foot rise. There are to be double quoins or headers in the alternate courses at both the upper and lower ends of the piers, and in the upper half of them there must be double headers in every course, not more than 8 feet apart, between which the wall may be made up of two widths of stone.

In the face of the side walls and on both sides of the division piers, checks 12 inches wide and 2 feet apart are to be cut within $2\frac{3}{4}$ feet of their extreme upper end, for the reception of stop timbers; they are to be made 3 inches deep at the top, increasing in depth downwards according to the batter of the respective walls, so that when the stones are in position the backs of the checks shall be plumb.

Below the breast wall, checks for stop timbers are also to be cut at the places indicated on the plan; they are to be 12 inches wide and 2 feet apart; those in the side walls will be $7\frac{3}{4}$ inches deep at the bottom, and run out to the line of the wall at $15\frac{1}{2}$ feet over the floor; and in the division piers they will be $8\frac{3}{4}$ inches deep at bottom and terminate at the height of $14\frac{1}{2}$ feet.

In the lower wings, offsets or steps are to be made in the different courses, from a point about 9 feet below the lower face top line of the breast wall, as represented on the plan.

COPING.—The breast wall coping must be at least 18 inches in height of course, and in lengths of not less than 4 feet. It must be 4 feet wide on top, increasing in width downward to the batter of the wall. The lower beds and joints of each stone must be kept full throughout; the top dressed fair and so as to have a declivity of one inch toward the upstream side. The different stones are to be connected with dowels at the joints, and secured with bolts to the course underneath.

The coping stones of the division piers are to be 3½ feet wide on top, increasing according to the batter of the walls, and the coping of the side walls is to be 3 feet wide on top, increasing in width downward to the face batter and to the rear frost batter; they must all be at least 15 inches in thickness, have full beds and joints, and be neatly boucharded on top.

The arrises of all the face stones in both the upper and lower sides of the breast wall, the division-piers, the sills, lintels, piers and sides of the sluice-ways, must all be kept good, and the whole dressed in such a manner that their upper and lower beds shall be parallel for at least three-fourths of their width, and the end joints squared for not less than 12 inches back from the face, and so dressed that when laid the horizontal and vertical joints shall not exceed, as previously stated, one-fourth of an inch thickness of mortar.

BACKING—to be of an approved class of large-sized, well-shaped stones, not less than six inches in thickness, laid on their broadest beds in full mortar, and bonded over and with each other throughout the wall.

In addition to the range of sheet piles to be placed in line of the breast wall, a counterfort of masonry, 4 feet thick and 7 feet in length, is to be carried up in connection with each of the side walls to within 4 feet of the top of the coping.

A puddle bed three feet in width is to be carried up in rear of side walls, as the works progress, to the full height of the upper reach.

SLUICE GATES—to be arranged to work vertically by means of lifting-screws; they are to be wedge-shaped on their bearing surface and water-tight only when closed. When in motion the gate will be carried on six friction rollers,—three on each side,—running on cast iron paths, secured to the packing plank, placed in recesses formed in the masonry for that purpose. These planks are to be of white oak, generally 2½ inches thick, fastened to the masonry and further secured by vertical guide timbers, fastened to the ends of the piers and wall above them by means of fox-tailed bolts seven-eighths (⅞) of an inch diameter, let 6 inches into the masonry, or by bolts driven into pine plugs, fitted into holes made in the wall for their reception.

The guide timbers are to be of white oak, 9½ inches by 7 inches, dressed with a plane, and must be grooved out for the ends of the guide roller shafts.

The path plates are to be fastened to the packing plank with wood screws one-fourth of an inch diameter, the holes for which must be countersunk, so that their heads, when in place, are wholly below the face of the plate.

GATES—to be formed of white oak timber scantling, arranged vertically, the middle pieces to be 5 inches by 7 inches, and the outside pieces 5⅞ inches by 8½ inches, all of which must be planed and properly jointed. Into the outer edge of each of the outside timbers three cast iron cheek plates are to be fitted through these plates, and the gate horizontal rods are to pass and form journals for the friction rollers. The ends of the rods are each to be turned up 9 inches, and have brass ferrules fitted on them, the

rods to be made to draw and hold the timbers firmly together, the ferrules to serve for butting pieces to both the rods and journals. The arrangement and manner of finishing the ends of the rods, and dimensions of the different parts will be readily understood by the working drawings which will be furnished.

The gates are each to be strengthened by two bridging trusses of cast iron, the ends of which are to rest in seats prepared in cheek plates to receive them ; the tension rods are to be 1 inch diameter and have large, flat, square heads and hexagon nuts. The bottom flange of the truss to stand half an inch clear of the face of the gate. Each of the gates to be opened and closed by means of a lifting-screw $2\frac{1}{4}$ inches diameter, made of mild steel, attached to a matrix and hand-wheel working in a casting placed on the bridge timber over the gates.

The coupling rods, eye bolts and attachments, both to the gates and screws, as well as the forms and dimensions of each part, will be given in detail on the working drawings.

BRIDGE.—To afford a convenient means of working the sluice-gates, a bridge or platform will be constructed above the upper line of the breast wall; it will be formed of stringers of pine timber covered with 2 or 3-inch pine plank, as may be directed. The stringers are to be 8 x 12 inches, except the range under the middle of the platform, which is to be 6 x 12 inches ; the two ranges next the breast wall are to be 8 inches apart and double, with distance pieces of white oak 6 inches thick, placed 6 feet apart, between them, and connected with screw-bolts one inch and a quarter diameter, which are to have large cast iron washers under both heads and nuts.

The bridge stringers are to be dressed and the upper ones chamfered and stop-chamfered where required. The wood-work of the sluice-gates must also be planed, and all such fittings and connections made as may be necessary to execute the work in the best and most substantial manner.

RUBBLE WALLS—In continuation of the weir walls, rubble walls of masonry laid in cement mortar, are to be built as represented on the general plan. They are to be built of large-sized, sound, flat-bedded and well-shaped stones, properly bonded over and with each other throughout the wall. Those on the front sides are to have their faces hammered or scabbled to lines corresponding to the positions they are to occupy in the work, and have headers $3\frac{1}{2}$ feet depth of bed in every course, not more than 7 feet apart.

The walls are to be 3 feet wide on top and have a batter of 2 inches or more to the foot on the front side, and on the rear side increase at the rate of 4 inches to the foot for the first 5 feet from the top, thence downward they are to be plumb. The coping stones must be at least 10 inches thick, three feet wide at top, increasing in width downwards to the batter on both sides. No piece to be less than three feet in length.

In rear of the walls (if so directed) a space of 15 inches in width is to be made up for such a height as may be requested, with small stones, quarry waste, or gravel, well rammed.

Where the lower extension walls connect with the wing walls of the weir, the face line of the varying or winding batter is to terminate within a distance of 30 feet from the end of the weir. The wall on the west side is to be extended until it intersects what was the side wall of the old structure, and the extension wall on the east side is to be carried as far into the lower dam as circumstances will permit. In both cases the seats for the walls must be sunk to such a depth as may be necessary to reach as good and firm a foundation as can be obtained.

In the event of longitudinal bearing timbers being required for a foundation, or even bearing piles, they must be provided, and the work done by the contractor at the rates stated in the tender.

The extension wall on the east side above the weir will be of a like class of work to that above described, except that the face batter will be one in twelve and the width at bottom increased, and such an offset made about half the height as will make the vertical sectional area of both walls alike at the same height.

Above the weir and on the line represented on the general plan, a road-way bridge is to be constructed, the abutments of which are to be of coursed masonry of a like class as that described for the side walls of the weir. The foundations for them are to be sunk from 13 to 15 feet below the water line, and, if necessary, must be prepared as provided for the walls below the weir. The bridge seats are to be 18 feet in length, 15 inches wide and 16½ inches deep at centre, and 14 inches at the sides below the level of the lock walls.

The coping stone of the abutments must be properly dressed for the position it is to occupy.

For the purpose of carrying the bridge, five ranges of piles are to be driven, four in each range, as shown on plan. The piles must be of white oak timber 12 inches diameter at the small end, and be satisfactorily driven to the depth required by the nature of the material at the place where they are situated.

Tenons, 4 inches by 10 inches and 7 inches long, are to be worked on the top of the piles, and cap pieces of white oak, 12 inches by 14 inches, are to be mortised and put on to them, and fastened by white oak draw-pins, having a draw of one-eighth of an inch. The top of the cap to be on the same level as the bottom of the bridge seats in the abutments.

The bridge is to be 18 feet wide, and carried by three ranges of double stringers—the outer ranges to be of 10 by 10-inch timbers, and the centre range 10 by 12-inch timbers—the timbers in each range to be spaced 5 inches apart. In the centre of each space a transverse beam, 10 by 6 inches, and about 26 feet long, is to be bolted to the under side of the truss beams by tie bolts 1¼ inches diameter, and spacing blocks of white oak, 10 by 6 by 6 inches, must be checked into and between the truss timbers, and large cast iron washers are to be put under the heads and nuts. The truss timbers are also to be fastened to the cap timber of the piers with bolts having large washers under their heads and nuts. To carry the floor plank, four ranges of longitudinal pine joists are to be secured to the transverse timbers and cap pieces with five-eighths (⅝) inch bolts. Bridging pieces of plank, 8 inches by 2 inches, are to be securely spiked between the joists and truss timbers. The tops of the joists and lower timbers are to be placed crowning 2 inches in the centre of the bridge. Guard rails, formed of posts and rails 6 by 6 inches, neatly dressed and stop-chamfered, are to be put on both sides of the structure. The posts to be fastened on the outside faces of the truss beams with wood screws 10 inches long and half an inch diameter, having neat cast iron washers under their heads; the rails to be mortised on to the posts and fastened with half-inch draw pins. Six-inch battens to be let half an inch into the posts and fastened to them with wood screws.

The rails to have stay-braces of wrought iron, 1½ inches diameter, attached to the transverse timbers and caps by wood-screws five-eighths (⅝) of an inch diameter and five inches long. The floor to be formed of two courses of plank, the lower one of which is to be of pine 2½ inches thick, 19 feet long and in widths of not more than eight inches;

spaced three inches apart and spiked to the joists and lower timbers of the outside truss with six-inch pressed spikes. The upper covering to be of 2-inch oak plank, in widths of seven inches, fastened to the lower course with five-inch spikes.

The plank to break joint every fourth course not less than three feet. All the plank must be laid or dubbed to a fair surface to allow the water to pass off freely.

PAINTING.—All the wrought and cast iron work connected with the bridges that is exposed to the direct action of the atmosphere, (lifting-screws excepted) must receive one coat of red oxide paint before it is fitted up, and the woodwork a priming coat of white lead and linseed oil. When the roadway bridge works, as well as those in the bridge over the weir, are in place, the whole (floors excepted) must receive two full coats of the best white lead and linseed oil paint, in such colors as may be directed; sufficient time must be given for each coat of paint to harden properly before the second or third coat is put on.

CONCRETE—where used in the work must consist of an approved quality of stone, broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole of the masonry of the weir, bridge abutments and extension walls below the weir, must be laid in mortar, made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of Canadian manufacture of the best approved quality, fresh from the manufactory, and, until used, must be protected from the influence of the weather, in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge. Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and then using as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stone and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that the wall on one side shall not be carried up more than one course higher than the wall on the other side.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course must be properly grouted up before another course in commenced.

Suitable derricks, or other approved machinery for handling and laying the stone, must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

The bulk sum tendered for unwatering the works must embrace the cost of maintaining the present dams, and any alterations that may be required to them either in the way of raising or strengthening them, or making them more secure, or for any other purpose necessary to keep out the water of Lake Ontario or the present canal, and to guard against leakage from either of these sources or from springs or surface drainage; also the cost and expense of providing and fitting up of such pumps and machinery as may be required for that purpose, together with all pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with unwatering the weir and other portions of the works during the progress of the operations, and up to the completion of the whole undertaking.

After the weir has been completed, the contractor, before interfering with the present roadway, must provide another convenient means for the public travel to pass, by the construction of a temporary bridge over the weir before the removal of the upper dam is commenced or the works connected with the permanent road bridge are proceeded with, other than providing the necessary materials for the works.

This temporary bridge may be rough, but it must be strong, have suitable approaches at both ends, and have a strong hand-railing on both sides of it and for such a distance beyond it as may be considered necessary, and be in all respects satisfactorily arranged and adapted to safely accommodate the public travel.

It is further to be clearly and distinctly understood that he (the contractor) shall be held strictly and legally liable and responsible for keeping this crossing in such a condition that it can be safely used during the whole time that the new bridge works are in progress, and that he will remove the temporary works when required; the whole to be done for the bulk sum stated in the tender for that purpose.

In all matters connected with the prosecution of the work, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations connected with the works, the contractor must be governed by the canal regulations and the interpretations put on them by the officer upon whom that duty devolves; he must, further, use every precaution to guard against interrupting, impeding or interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Railways and Canals, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed drawings, arranged, modified and adapted to the circumstances and the locality and for all such parts of the structures as may be considered necessary for the full understanding of the design will be furnished as the works proceed.

If any alteration be rendered necessary by any cause or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed, by an authorized officer, for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, store-houses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials; furnish all plant, tools, vessels, machinery, equipment, labor and everything required for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described, and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent*, on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the names of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Railways and Canals that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 20th day of April, 1880.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 20th September, 1879.

APPENDIX No. 3.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTION No. TWO of the Enlargement.

This section is about 2,700 feet in length, and extends from a little beyond the road between Port Dalhousie and St. Catharines, through what is known as "May's Ravine," to the pond above the outlet of the present canal.

It includes the formation of the canal and banks where necessary for the distance above stated—the excavation of lock and weir pits, cutting raceways, etc., etc.

It also embraces the construction of two lift locks (gates excepted), two regulating weirs, bridge abutments, and such other structures as are hereinafter described, or the contractor may be called upon to execute.

The canal will, for the most part, be located as shown on the general plan exhibited —the centre line corresponding nearly with that marked out on the ground, but the Department of Railways and Canals reserves to itself the right of changing the whole or any part of the line, as much as 200 feet, either to the right or to the left of that represented, and of altering the position of any or all of the structures, 300 feet, either upwards or downwards, of that indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made 100 feet wide at bottom, with a depth of 13 feet below the assumed water line; side slopes to be two horizontal to one vertical, in clay or earth excavation; and in rock, the sides are to have an inclination of one-fourth to one.

A continuous towing path is to be formed on both sides of the canal, 15 feet wide on top and four feet over the water surface, increasing where the ascent is made to the next reach, at the rate of about 1 in 15.

CLEARING, GRUBBING, MUCKING, ETC.—From the space to be occupied by the canal, its banks, basins and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brush of every description, must be burnt, or otherwise removed, but so as not to do any damage to the adjacent lands.

All trees standing beyond the space mentioned, that by falling might injure the banks, or obstruct navigation, are to be cut down and removed, if directed. All the clearing, grubbing, and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge, before the work of excavation is commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth, as may be directed, for the entire space to be occupied by the bank; the sod or loose earth must be placed at such a distance from the banks as the officer in charge may require; and in all cases, when making up a bank, care must be taken to place the best, most solid, and water-tight earth in that part of the bank adjoining the canal, and to place all coarse materials, or such as are permeable to water, in the outer extremity of the banks, or if required, to remove them altogether beyond the limits of the same.

The material excavated from the different reaches, water-courses, raceways, lock and weir-pits, when of a suitable kind, must be hauled and placed wherever it is required to make up either the banks of the canal, or the basins, or embankments behind the locks and weirs, within a distance of 1,000 *feet; the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given and lines marked out by the engineer.

The slopes, both in cutting and embankment, are, as already stated, to be *two* horizontal to *one* vertical, made uniform, and trimmed neatly, and so as to present a fair outline corresponding to the line of the canal.

No ground to be broken within ten feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making up an embankment, the borrowing pits will generally be at a place which is to form part of basin; but when a borrowing pit is outside of a bank, where there is no basin, the excavation must be made either in the form of a ditch, or of such other shape and dimensions as may be required.

Where it is necessary to change the course of small streams, or for the purpose of carrying off surface water or other drainage, on any part or the whole of a section, the work is to be done by the contractor, and the material excavated must be hauled and used to make up the banks of the canal or basins, as may be directed.

In the banks adjoining basins, openings of such dimensions, and in such a position as required, are to be left for the free ingress and egress of the water.

Their sides are to be formed either of rubble masonry of a substantial class, laid in hydraulic cement mortar, or of cribwork, filled with stone, as may be hereafter determined.

When the basin is large, or circumstances may require, there are to be either separate openings through a bank, or a large one divided by piers of coursed masonry, built of large, flat-bedded stones, and carried to a like height as the abutments, so as to form a bearing for the bridge stringers.

In cases where the depth of excavation exceeds 17 feet, the banks must be cut down to that height, for the width of the towing path, together with such a space for ditches as may be required.

Where it may be necessary to spoil material removed from a cut, the foot of the spoil bank slopes must be at least 20 feet back from the edge of the cut, and their upper surface made of an uniform height, with an inclination outwards of 1 in 16 and side slopes of 2 to 1.

When forming the banks of the canal, or those of the basins, or embankments in rear of the locks and weirs, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer, to assist in consolidating the material.

PUDDLE BEDS,—When necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognised, namely: "earth and rock;" the former to embrace all kinds of materials found in the cuttings or borrowing pits, except absolutely connected "quarry rock" and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing path, and completing everything connected with the excavation of the section, in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But, as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

LOCKS.—The locks are to be 270 feet in length between the gate quoins, and 45 feet in width between the side walls, at the level of the lower reach. They are to be constructed of dressed stone masonry laid throughout in hydraulic cement mortar, and placed on foundations prepared as hereinafter described.

The pits excavated for them are to be made of suitable dimensions to admit the side and wing walls, and to correspond with such lines as will be marked out on the ground by the officer in charge.

In rock the sides of the cut are to be made perpendicular, and a space of one foot left in the rear of the walls for concrete; and in clay-cutting such slopes are to be formed as may be required for stability.

The bottom must, in all cases, be trimmed smooth and level, at a proper height, to give a fair and uniform bearing to the foundation timbers or base of the walls.

The material excavated from the lock pits, when of a suitable kind, must be used for the purpose of making-up the banks, hauled and placed in like manner as described for that taken from the reaches and other portions of the work.

If solid and suitable rock, in thick layers, is found at the proper level at the place where a lock is to be built, the walls will be commenced upon it, without an artificial foundation; but if the rock be unsound—the fissures in it numerous—the strata thin or irregular, a floor of pine timber, covered with 3-inch plank, will be laid at a height to form a bearing surface for the walls, and a similar course will be adopted where the foundation is of earth or clay.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length, to reach across the chamber, and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

When on clay they are to be laid 6 inches apart through the chamber, above the upper mitre still, and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn, and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches in diameter,) passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through, and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &C.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, he trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best materials for that purpose which can be obtained in that vicinity; cut, mixed, prepared, and laid as directed by the officer in charge.

SHEET PILES—To be of 4-inch pine plank, placed close vertically, generally, 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every three feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inch in diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned, and secured in the manner shown on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 3 inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons, and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canva well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, 3½ inches wide, and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½-in.) diameter, have upset heads, and be well ragged at the points.

Where the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATER.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill, platform checks ard to be cut into the rock, 4 inches or more in depth, and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber, 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid in for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, $1\frac{1}{4}$ inches diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described, are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than that occupied by the platforms, there are to be timbers 12 inches square, laid 6 inches apart; also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, $1\frac{1}{2}$ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The locks are to be from 12 to 14 feet lift, and the side walls carried up to 2 feet over the surface water level of the upper reach with which they are connected. The chamber walls are to be 10 feet wide at bottom, with counterforts in rear, 6 feet long, in line of wall, and 3 feet projection, placed not more than 12 feet apart; the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping; and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound, and durable stones; those which form the face work must be free from drys, seams, or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted,) laid so that the beds and end joints shall not exceed $\frac{3}{8}$ of an inch.

CUT STONE—to be neatly dressed and boucharded; made square, bevelled, or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than 2 and 3 feet depth of bed on the alternate courses. In each course must be headers of at least 2 feet length of face, and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers, in the alternate courses, must be at least 1½ times their height, and the headers 2¼ times their height; and in all cases the tail of a header must have a width of ⅔ the length of its face.

HOLLOW QUOINS,—to be alternately headers and stretchers, the former at least 4½ feet face, and 5½ feet depth of bed; the latter 5½ feet face and 4½ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet, and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled as shewn on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain-wells in the positions indicated on the plan; each well will be 2 feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK,—For the face of the chamber wall, may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face, and 4 feet depth of bed placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed $\frac{3}{8}$ of an inch.

BACKING—to consist generally of well-shaped stones, not less than 6 inches in thickness, and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain-wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least $6\frac{1}{2}$ feet square on top and two feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed $\frac{1}{4}$ of an inch.

A dowel, 4 inches long, of $1\frac{1}{2}$ inch iron, to be inserted in every joint 15 inches back from the face, and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be 7 feet wide at bottom, 3 feet on top, built of coarse rubble masonry, and covered with suitable coping.

When locks are wholly or in part in rock cutting the space between the back of the walls and rock must be made up of concrete, well mixed and pounded and carried up simultaneously with the walls.

CONCRETE—where used, must consist of an approved quality of stone broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement, and clean sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar, made of the best hydraulic cement, mixed with clean large-grained sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand, to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them is allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered properly, cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at back of the walls, made up in the manner already described, are to be 25 feet in width, and have a declivity of 6 inches outwards from the lock.

RUBBLE WALLS,—forming the extension of the wings at the head and foot of the locks, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over, and with each other, and laid in cement mortar for such a distance below the lock as may be directed.

The walls are to be built to such lines as will form a suitable connection between the locks, the slope walls, and the inner face of the banks, or retaining walls, as the case may be; and the face of the stones are to be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

REGULATING WEIRS—arranged as indicated on the general plans, or in such other positions as may be required, or to be constructed as herein described. The pits for them are to be sunk at least 5 feet below the surface level of the lower reach, and made sufficiently large to admit the side walls. The material excavated from these pits, as well as that from the raceway or water-courses leading to and from them, is to be used for forming banks where required, and must be hauled and placed in the manner previously described.

The bottom of the pit must be trimmed to a level and uniform surface to receive the foundation timbers, which are to be of pine, 12 inches square, laid 12 inches apart, and so as to rest on mud sills placed within the line of the side walls, and on the bottom throughout their entire length. The space between the timber to be filled with a good description of puddle, well beaten down; floor to be of 3-inch pine plank, laid so as to break joint every 3 feet in width of planking, and be well fastened with white oak treenails, 9 inches long and 1½ inches in diameter; two in each end of a plank and one on alternate sides at every crossing of a timber. Below the breast wall and between the wings, a second course of plank, 2 inches in thickness, is to be laid and fastened as may be directed.

There are to be three ranges of sheet piles across the foundation; one above and another below the breast wall, and the third at the lower end of the wings; they are all to be of like dimensions, placed and secured as stated for those in lock foundations.

MASONRY—Walls are to be built in the positions, and be of the respective dimensions represented on the general plan; throughout they must consist of sound and durable stones, free from seams and other defects, laid in full mortar, on their natural beds.

The wings are to be of "Rock Work," carried up to a batter of 1 in 12, face 18 inches, and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course, dressed and laid so that the beds and end joints shall not exceed ⅜ of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work laid to a batter of about 4 inches to the foot rise.

There are to be six sluice-ways through this wall, each four feet wide and 4 feet high, the sides of which are to be dressed smooth—sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

BREAST WALL COPING—To be four feet wide on top, increasing in width downwards to the batter of the wall, the lower bed and joints must be kept full throughout, and the top dressed fair and so as to have a declivity of 1 inch towards the up-stream side.

A centre pier is to be carried up above the breast wall to form a bearing for a bridge; it is to be 5½ feet wide at bottom—batter on both sides so as to be 4 feet wide at

top, and built in courses corresponding in height to those of the breast wall, and of such a width of bed that two stones will make up the thickness of the pier, and have headers not more than 9 feet apart passing entirely through the wall.

The coping to be dressed on top, and of the full width of the wall. Offsets on the different courses of the lower wings to be made from 5 feet over the level of the lower reach, as represented on plan. Wing coping to be at least 12 inches high, 3½ feet wide with beds and joints kept full throughout, and top neatly boucharded.

In addition to a range of piles to be placed in line of the breast wall, a counterfort of masonry 4 feet thick, and at least 7 feet in length, will be carried up in rear of each wing to the height of the water level of the upper reach.

BACKING—to be of a like class of stone, and laid in like manner as described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared as stated for other portions of the works.

A puddle bed 3 feet in width is to be carried up in rear of the side or wing walls, to the full height of the water level of the upper reach. The material used for this purpose as well as for the puddle between the foundation timbers, and for the sheet pile trenches, must be of the best and most suitable kind that can be obtained on the Section, or in the vicinity of the work.

The lower lock and weir will be connected by a wall of a heavy and substantial class of masonry, laid throughout in cement mortar, on a foundation of timber and plank placed at such a level as the nature of the bottom may require.

The timbers forming the foundation are to be of pine 12 inches square, in length of from 30 to 50 feet, counterhewn, laid longitudinally in five continuous ranges—one corresponding with the front line, and another with the rear line of the wall—the other three intermediate ranges being placed so as to leave the intervening spaces nearly equal; a timber is also to be placed at the rear line of each counterfort. They must all be laid so that no two joints on adjoining ranges shall be nearer than 6 feet of each other; and in all cases the timbers must rest uniformly on the bottom throughout their entire length.

All the spaces between them must be filled with the best description of puddle, well cut, rammed, and pounded, or with concrete, as may be directed.

The tops of the timbers, when laid, if required, must be dubbed to an uniform surface to receive the covering, which is to consist of 3-inch pine plank laid obliquely to close joints, and secured with 7-inch pressed spikes, two in each end and one at every crossing of a timber.

A range of sheet piles is to be placed along the toe of the wall for the whole distance, or to such other extent as may be required; where used they are to be of like dimensions, secured, and the trenches made for them filled, in the manner discribed for those in the locks.

In case the nature of the material at the present level of the bottom of the ravine is unsuitable for a foundation of the kind above described, the contractor will be required to furnish and drive such a number of piles as may be necessary to form a proper bearing for the wall, as well as to provide and drive a continuous range of close sheet piles at the toe of the wall on the upper side.

The top of the piles to be cut off to an uniform height, and ranges of cross sills secured to them, on which longitudinal sills are to be placed, 12 inches apart, and for at least one foot below the top of the piles all soft material must be removed, and the whole of the spaces afterwards filled with concrete to the top of the sills. The plank is then to be laid and secured and the masonry commenced.

The walls are to be 9 feet wide at bottom, with counterforts in rear six feet long in line of wall, and three feet projection, at intervals of 12 feet.

The face of the wall to have a batter of one in 12, and the back carried up plumb to within five feet of the top, where the counterforts will terminate, and the whole batter uniformly to the rear line of the coping.

From the foundation upwards to within 4 feet of the top the face of the wall is to be of coursed work, the stones of which are to be scabbled and dressed so that they can be laid throughout in such a manner as not to exceed ($\frac{5}{8}$) five-eighths of an inch mortar joints. They are not to be less than nine inches in height, but it is not necessary that a course should be continuous of the same height for a distance of more than 20 feet, provided the stones are checked where the course is broken, so as to admit of securing in all cases a bond of at least 12 inches.

The face of the stones must invariably be picked or scabbled to lines corresponding to the position they are to occupy in the work, and in depth of bed and otherwise they must be of like dimensions (20 or 30 inches in depth of bed in alternate courses, and have as many similar sized headers, 4 feet depth of bed in every course) as described for the chamber work of the locks.

For the upper 4 feet in height, the face of the wall is to be of cut stone of like dimensions, dressed throughout in every respect, and laid to $\frac{3}{16}$ of an inch mortar joints, and bonded as described for the facework at both ends of the locks, *i.e.* the stones must be at least *two* and *three* feet depth of bed in the alternate courses, with headers in each course 4½ feet depth of bed, placed not more than 9 feet apart.

BACKING—to be of a like class of stone, and laid as described for the rear part of the lock walls.

COPING STONES—to be 4 feet wide on top, increasing in width downwards, corresponding to the frost batter in the rear, and to the face batter of the walls. They must be at least 15 inches in height of course, 4 feet long in line of wall, be dressed in every respect, and laid to such joints, and be secured with dowels in like manner as described for the coping on the chamber walls of the locks.

At the lower end of this section, a line of cribwork 16 feet in width, and extending about 300 feet in length, is to be constructed and sunk on each side of the entrance to Lock No. 2, in the positions indicated on the plan.

The cribs are to be close work, built in lengths of 25 to 35 feet, and of a height when sunk that their top shall be 18 inches under the present water levels, their sides and ends are to consist of timbers 11 inches square; ties to be flatted of a size to square 9 by 10 inches; and the floor timbers are to be 9 inches thick.

FRAMING.—At the angles of the cribs the side and end timbers are to be connected by double-bevelled dovetails and at each corner in every course, a rag-bolt 12 inches long and five-eighths ($\frac{5}{8}$) of an inch diameter, is to be driven through the dovetail. The cross ties are not to be more than 10 feet apart, and dovetailed 4 inches into the timbers under

and over them in the manner directed. A rag-bolt 2 feet long, and seven-eighths ($\frac{7}{8}$) of an inch diameter, is to be driven through the head of each tie, passing through the course in which it rests and into the course below.

The floor timbers are to be laid transversely, pass through the respective cribs, and rest on either the first or second course of side timbers to which they are to be fastened.

If considered necessary, the cribs are to be further secured by four or more ranges of vertical binders placed on the inside, and fastened at every crossing of a timber from the bottom tier upwards.

For the cribs, cedar, ash, tamarac or hemlock timber may be used, if straight and of good quality, and free from shakes, sapwood, unsound knots, or other defects.

The cribs are either to be filled with stone ballast or clay taken from the excavation, as may be subsequently determined.

When the whole shall have been sunk, well filled, and settled in their respective berths, the contractor must take the first opportunity of the water being low to make the sides of an uniform height, at about 18 inches under ordinary water level, and to put in such intermediate cross ties as may be required.

The filling must then be well packed in between and under the ties; and along the front top side of the cribwork for its entire length, a platform of five feet in width at the outer end and 7 feet wide near the lock, is to be laid of pine timber 12 inches in depth; the timbers of which must be in lengths of 30 feet and upwards, laid throughout so as to break joints at least 5 feet with the adjoining range, and fastened to the cross ties as directed.

On this platform a wall is to be carried up to about the same height as the lock coping, gradually diminishing outwards to 5 feet over the water surface.

The wall is to be of a heavy class of masonry (laid in hydraulic cement mortar) of a similar character to that described for the lower part of the wall between the regulating weir and the head of the lock. The coping to be $3\frac{1}{2}$ feet wide, scabbled, and laid to joints not exceeding five-eighths ($\frac{5}{8}$) of an inch.

An embankment 25 feet or more, in width on top is to be formed in rear of the walls and cribwork built at the entrance; the materials for which are to be taken from the lock pit and other parts of the excavation.

These banks, after being fully consolidated, are to be protected with stone placed in an indent cut from 2 feet below the water line up to 2 feet over it.

At the head of the upper lock, on this section, there will be a road crossing; to provide for which, walls in continuation of those of the lock will be built to form abutments, as shewn on plan.

They will rest on a foundation of timber and plank, and have sheet piles at the toe of the walls, and will be of a like class of masonry as described for the chamber walls of the locks; carried to the height shewn on the detailed plan to be furnished, recessed, curved, and otherwise adapted for the toe and turntable on which the bridge is to move.

The coping stones to be at least 15 inches in depth, and of large dimensions, those under the turntable to form a circle to support the trackway for the rollers.

The pivot stone to be not less than 5 feet square, and 2 feet depth of bed.

In line with the swing bridge, two abutments and a centre pier will be built of coursed scabbled masonry, laid in hydraulic cement mortar, to receive the superstructure of a fixed bridge over the raceway.

The superstructure of the swing, also the fixtures and machinery required for working it, as well as the lock gates, will be made a separate contract; but all the masonry required is to be done by the contractor for the locks.

The contractor must construct coffer dams wherever it may be necessary to keep out the water of the present canal or to guard against leakage, springs, or surface drainage.

The cost of all such dams, together with the expenses of pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with unwatering the lock and weir pits, and all other portions of the works during their progress, and up to the full completion of the whole, and the satisfactory removal of all coffer dams, and other temporary works, must be embraced in the bulk sum stated in the tender for unwatering the works.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction; but detailed working drawings, arranged, modified, and adapted to each lock and weir foundation, and for all such other parts of the structures as may be required, will be furnished as the work proceeds.

Before the present public road is cut away, or in any way disturbed, the contractor must provide, at his own cost and expense, another and satisfactory means for the public travel to pass, either by the formation of another road, or the construction of a temporary bridge, or both, as may be required. It being clearly and distinctly understood that he (the contractor) shall be held legally liable and responsible for keeping the crossing in such a condition that it can be safely used during the whole time that the bridge is in progress of construction.

MATERIALS, SERVICE GROUND, &C.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be required for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery, and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature and the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

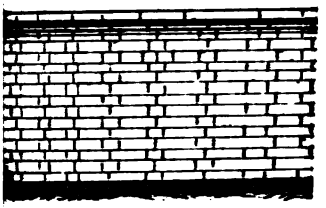
Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the first day of April, 1877.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 3rd January, 1874.



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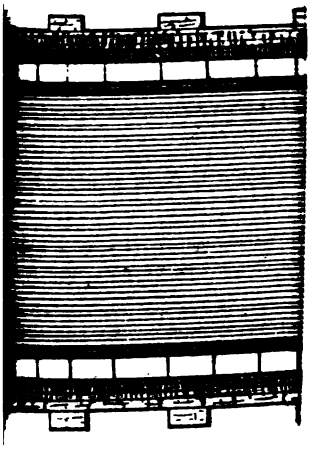

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APPENDIX No. 4.

WELLAND CANAL.

GENERAL SPECIFICATION for the Enlarged Canal between THOROLD and PORT DALHOUSIE, SECTIONS 3, 5, 7, 13 *and* 14.

The canal, will, for the most part, be located as shown on the general plan exhibited—the centre line corresponding nearly with that marked out on the ground, but the Department of Public Works reserves to itself the right of changing the whole, or any part of the line, as much as two hundred feet, either to the right or to the left of that represented, and of altering the position of any or all of the structures, three hundred feet, either upwards or downwards, of that indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made one hundred feet wide at bottom, with a depth of 13 feet below the assumed water line; side slopes to be 2 horizontal to 1 vertical, in clay or earth excavation; and in rock, the sides are to have an inclination of $\frac{1}{4}$ to 1.

A continuous towing path is to be formed on both sides of the canal, 15 feet wide on top, and four feet over the water surface, increasing, where the ascent is made to the next reach, at the rate of about 1 in 15.

CLEARING, GRUBBING, MUCKING, &c.—From the space to be occupied by the canal, its banks, basins and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brush of every description, must be burnt, or otherwise removed, but so as not to do any damage to the adjacent land.

All trees standing beyond the space mentioned, that by falling might injure the banks, or obstruct navigation, are to be cut down and removed, if directed. All the clearing, grubbing and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge, before the work of excavation is commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth, as may be directed, for the entire space to be occupied by the bank ; the sod or loose earth must be placed at such a distance from the banks as the officer in charge may require ; and in all cases when making up a bank, care must be taken to place the best, most solid and water-tight earth in that part of the bank adjoining the canal, and to place all coarse materials, or such as are permeable to water, in the outer extremity of the banks, or if required to remove them altogether beyond the limits of the same.

The material excavated from the different reaches, water-courses, raceways, lock and weir-pits, when of a suitable kind must be hauled and placed wherever it is required to make up either the banks of the canal, or the basins, or embankments behind the locks and weirs, within a distance of 1,000 feet ; *the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given and lines marked out by the engineer.

The slopes, both in cutting and embankment, are, as already stated, to be *two* horizontal to *one* vertical, made uniform and trimmed neatly, and so as to present a fair outline corresponding to the line of the canal.

No ground to be broken within 10 feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making up an embankment, the borrowing pits will generally be at a place which is to form part of basin ; but when a borrowing pit is outside of a bank, where there is no basin, the excavation must be made either in the form of a ditch, or of such other shape and dimensions as may be required.

Where it is necessary to change the course of small streams, or for the purpose of carrying off surface water, or other drainage, on any part, or the whole of a section, the work is to be done by the contractor, and the material excavated must be hauled and used to make up the banks of the canal or basins, as may be directed.

In the banks adjoining basins, openings of such dimensions, and in such a position as required, are to be left for the free ingress and egress of the water.

Their sides are to be formed either of rubble masonry, of a substantial class laid in hydraulic cement mortar; or of crib-work, filled with stone, as may hereafter be determined.

When the basin is large, or circumstances may require, there are to be either separate openings through a bank, or a large one divided by piers of coursed masonry, built of large, flat-bedded stones, and carried to a like height as the abutments, so as to form a bearing for the bridge stringers.

In cases where the depth of excavation exceeds 17 feet, the banks must be cut down to that height for the width of the towing-path, together with such a space for ditches as may be required.

Where it may be necessary to spoil material removed from a cut, the foot of the spoil bank slopes must be at least 20 feet back from the edge of the cut, and their upper surface made of an uniform height, with an inclination outwards of 1 in 16 and side slopes of 2 to 1.

When forming the banks of the canal, or those of the basins or embankments in rear of the locks and weirs, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or wagons and laid on in layers not exceeding 1 foot in depth at a time ;* and if the work be done at a dry season of the year, water must be thrown over each layer, to assist in consolidating the material.

PUDDLE BEDS,—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "Earth and Rock;" the former to embrace all kinds of materials found in the cuttings or borrowing pits, except absolutely connected "Quarry Rock" and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing path, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner, that when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

LOCKS—The locks are to be 270 feet in length between the gate quoins and 45 feet in width between the side walls, at the level of the lower reach. They are to be constructed of dressed stone masonry laid throughout in hydraulic cement mortar, and placed on foundations prepared as hereinafter described.

The pits excavated for them are to be made of suitable dimensions to admit the side and wing walls, and to correspond with such lines as will be marked out on the ground by the officer in charge.

In rock the sides of the cut are to be made perpendicular, and a space of one foot left in the rear of the walls for concrete; and in clay cutting such slopes are to be formed as may be required for stability.

The bottom must, in all cases, be trimmed smooth and level, at a proper height, to give a fair and uniform bearing to the foundation timbers, or base of the walls.

The material excavated from the lock pits, when of a suitable kind, must be used for the purpose of making up the banks, hauled and placed in like manner as described for that taken from the reaches and other portions of the work.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where a lock is to be built, the walls will be commenced upon it, without an artificial foundation; but if the rock be unsound—the fissures in it numerous—the strata thin or irregular, a floor of pine timber, covered with 3-inch plank, will be laid at a height to form a bearing surface for the walls, and a similar course will be adopted where the foundation is of earth or clay.

FOUNDATION TIMBERS—to be of pine timber, 13 inches square, of the full length to reach across the chamber, and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

When on clay they are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces along side of them must be well filled with puddle and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts (1½ inches in diameter) passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &c.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed 2½ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best materials for that purpose which can be obtained in that vicinity; cut, mixed, prepared, and laid as directed by the officer in charge.

SHEET PILES—To be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inch in diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned, and secured in the manner shown on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end, they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½-in.) diameter, have upset heads, and be well ragged at the points.

Where the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATER.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms. checks are to be cut into the rock, 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth. a piece of duck or canvas, well saturated with white lead, must be laid in for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, 1¼ inches diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described, are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than that occupied by the platforms, there are to be timbers 12 inches square, laid 6 inches apart, also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, 1½ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The locks are to be from 12 to 14 feet lift, and the side walls carried up to 2 feet over the surface water level of the upper reach, with which they are connected. The chamber walls are to be 10 feet wide at bottom, with counterforts in rear, 6 feet long in line of wall, and 3 feet projection, placed not more than 12 feet apart—the recesses are to be 2 feet 8 in. deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four;* but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping; and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound and durable stones; those which form the face work must be free from drys, seams, or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted,) laid so that the beds and end joints shall not exceed $\frac{3}{4}$ of an inch.

CUT STONE—to be neatly dressed and boucharded; made square, bevelled, or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than 2 and 3 feet depth of bed on the alternate courses. In each course must be headers of at least 2 feet length of face, and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers, in the alternate courses, must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{4}$ times their height; and in all cases the tail of a header must have a width of $\frac{2}{3}$ the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least $4\frac{1}{2}$ feet face and $5\frac{1}{2}$ feet depth of bed; the latter $5\frac{1}{2}$ feet face and $4\frac{1}{2}$ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also $4\frac{1}{2}$ by $5\frac{1}{2}$ feet, and $5\frac{1}{2}$ by $4\frac{1}{2}$ feet, laid alternately out-bond and in-bond, bevelled as shewn on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain-wells in the positions indicated on the plan; each well will be 2 feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains; and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face, and 4 feet depth of bed placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed $\frac{3}{8}$ of an inch.

BACKING—to consist generally of well-shaped stones, nor less than 6 inches in thickness, and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must, in all cases, be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls; except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain-wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top and two feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face, and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be 7 feet wide at bottom, 3 feet on top, built of coarse rubble masonry, and covered with suitable coping.

When locks are wholly or in part in rock-cutting the space between the back of the walls and rock must be made up of concrete well mixed and pounded, and carried up simultaneously with the walls.

CONCRETE,—where used, must consist of an approved quality of stone broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement and clean sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar, made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings, provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand, to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of the frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work, before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered properly, cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at back of the walls, made up in the manner already described, are to be 25 feet in width and have a declivity of 6 inches outwards from the lock.

RUBBLE WALLS,—forming the extension of the wings at the head and foot of the locks, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over and with each other, and laid in cement mortar for such a distance below the lock as may be directed.

The walls are to be built to such lines as will form a suitable connection between the locks, the slope walls, and the inner face of the banks or retaining walls, as the case may be; and the face of the stones are to be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

REGULATING WEIRS,—arranged as indicated on the general plans, or in such other positions as may be required, are to be constructed as herein described.

The pits for them are to be sunk at least 5 feet below the surface level of the lower reach, and made sufficiently large to admit the side walls. The material excavated from these pits, as well as that from the raceway, or water courses leading to and from them, is to be used for forming banks where required, and must be hauled and placed in the manner previously described.

The bottom of the pit must be trimmed to a level and uniform surface to receive the foundation timbers, which are to be of pine, 12 inches square, laid 12 inches apart, and so as to rest on mud sills placed within the line of the side walls, and on the bottom

throughout their entire length. The space between the timber to be filled with a good description of puddle, well beaten down; floor to be of 3-inch pine plank, laid so as to break joint every 3 feet in width of planking, and be well fastened with white oak treenails, 9 inches long and 1½ inches in diameter, 2 in each end of a plank and one on alternate sides at every crossing of a timber. Below the breast wall and between the wings, a second course of plank, 2 inches in thickness, is to be laid and fastened as may be directed.

There are to be three ranges of sheet piles across the foundation; one above and another below the breast wall, and the third at the lower end of the wings; they are all to be of like dimensions, placed and secured as stated for those in the lock foundations.

MASONRY—Walls are to be built in the positions, and be of the respective dimensions represented on the general plan; throughout they must consist of sound and durable stones, free from seams and other defects, laid in full mortar on their natural beds.

The wings are to be of "Rock Work," carried up to a batter of 1 in 12, face 18 inches, and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more 10 feet apart in every course, dressed and laid so that the beds and end joints shall not exceed ⅜ of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work laid to a batter of about 4 inches to the foot rise.

There are to be six sluice-ways through this wall, each 4 feet wide and 4 feet high, the sides of which are to be dressed smooth—sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

BREAST WALL COPING—to be four feet wide on top, increasing in width downwards to the batter of the wall, the lower bed and joints must be kept full throughout, and the top dressed fair and so as to have a declivity of 1 inch towards the up-stream side.

A centre pier is to be carried up above the breast wall to form a bearing for a bridge; it is to be 5½ feet wide at bottom—batter on both sides so as to be 4 feet wide at top, and built in courses corresponding in height to those of the breast wall, and of such a width of bed that two stones will make up the thickness of the pier, and have headers not more than 9 feet apart, passing entirely through the wall.

The coping to be dressed on top, and of the full width of the wall. Offsets on the different courses of the lower wings to be made from 5 feet over the level of the lower reach, as represented on plan. Wing coping to be at least 12 inches high, 3½ feet wide with beds and joints kept full throughout, and top neatly boucharded.

In addition to a range of piles to be placed in line of the breast wall, a counterfort of masonry 4 feet thick, and at least 7 feet in length, will be carried up in rear of each wing to the height of the water level of the upper reach.

BACKING—To be of a like class of stone, and laid in like manner as described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared as stated for other portions of the works.

A puddle bed 3 feet in width is to be carried up in rear of the side or wing walls to the full height of the water level of the upper reach. The material used for this purpose as well as for the puddle between the foundation timbers, and for the sheet pile trenches, must be of the best and most suitable kind that can be obtained on the section or in the vicinity of the work.

On Section No. 5,—at the head of the lower lock, there will be a road crossing, to provide for which walls in continuation of those of the lock will be built to form bridge abutments.

They will rest on a foundation of timber and plank, and have sheet piles at the toe of the walls, and will be of a like class of masonry as described for the chamber walls of the locks, carried to the height shewn on a detailed plan to be furnished; recessed, curved, and otherwise adapted for the toe and turntable on which the bridge is to move.

The coping stones to be at least 15 inches in depth and of large dimensions; those under the turntable to form a circle to support the track-way for the rollers.

The pivot-stone to be not less than 6 feet square, and two feet depth of bed.

The upper wings and centre pier of the adjoining weir, to be extended so as to form bearings for a fixed bridge over the raceway.

The superstructure of the swing, also the fixtures and machinery for working it, will be made a separate contract; but all the masonry required is to be done by the contractor for the locks.

Before the present public road is cut away, or in any way disturbed, the contractor, must provide, at his own cost and expense, another and satisfactory means for the public travel to pass, either by the formation of another road, or the construction of a temporary bridge, or both as may be found necessary; and must put up and maintain all such fences as may be required for public safety.

It being clearly and distinctly understood that he (the contractor) shall be held legally liable and responsible for keeping everything connected with the crossing in such a condition that it can be safely used during the whole time that the bridge is in progress of construction.

On Section No. 7—the abutments and pier for a bridge in line of the road from St. Catharines to Queenstown are to be constructed of masonry in the position indicated on the general plan.

The centre pier of the bridge to be built either in three separate blocks, or in one continuous range, as may be subsequently determined. Both the abutments and pier to be placed on a foundation of timber and plank, laid so that the top of the plank shall be at least one foot below the bottom of the canal.

The face stone of the centre pier to be 2 and 3 feet bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones to be kept full, and dressed so as to lay to joints of ⅜ of an inch; and the face picked or scabbled so as to have a batter of one in twenty-four.

The heart of the wall to be made up with flat-bedded stone not less than 3 feet area of bed, and of the full height of the face stone; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed $\frac{5}{8}$ of an inch, and the vertical joints not be more than one inch and a quarter.

All the stones to be well bonded over and with each other, laid in hydraulic cement mortar, and the wall well grouted as the work proceeds.

The abutments will be of a like class of masonry as described for the chamber walls of the locks—recessed, curved, and otherwise adapted for the toe of the bridge, and they, as well as the centre pier, are to be carried up to the height shewn on a detailed plan to be furnished.

Coping stones to be at least 15 inches in depth, and of large dimensions; those immediately under the turntable to form a circle to support the track-way for the rollers. The pivot-stone to be not less than 6 feet square and 2 feet depth of bed.

On both sides and ends of the centre pier a close range of piles is to be driven down to fully 6 feet under the canal bottom, and their tops to be at least 6 feet over the surface water line; they are to be properly capped and otherwise satisfactorily secured at top.

Before the present public road is cut away, or in any way disturbed, the contractor must provide at his own cost and expense, another and satisfactory means for the public travel to pass, either by the formation of another road, or the construction of a temporary bridge, or both, as may be found necessary; and he must put up and maintain all such fences as may be required for public safety.

It being clearly and distinctly understood that he (the contractor) shall be held legally liable and responsible for keeping everything connected with the crossing in such a condition that it can be safely used during the whole time that the bridge is in progress of construction.

On Section No. 12—The lower wings of Lock No. 17 are to be extended to form bearings for a swing bridge to carry the traffic of the Great Western Railway.

The walls are to be placed on a foundation of timber and plank, laid at the depth, and secured in the manner described for the lock foundations.

The east abutment, and both sides of the centre piers, are to be faced with cut stone of like dimensions, dressed, laid, and bonded as stated for the facework at both ends of the locks, *i.e.* the stones must be at least *two* and *three* feet depth of bed in the alternate courses, with headers in each course $4\frac{1}{2}$ feet depth of bed, placed not more than 9 feet apart.

They are all to be dressed to a batter of one in twenty-four, have their arrises kept good, upper and lower beds parallel, and end joints full for at least two-thirds the depth of their beds. The backs of the stones to be hammered or picked off to such lines that the backing when laid may form with them joints not exceeding one inch in width.

The west abutment is to be of a like class of masonry as that of the chamber walls of the locks, and placed on a foundation of timber and plank.

At the toe of this wall, as well as at the westerly side of the centre pier, and across the canal at the lower end of the foundation, ranges of sheet piles are to be put in, and secured in like manner as stated for those at other parts of the works.

The whole of the walls connected with the bridge to be backed up with large-sized, flat-bedded stone laid throughout in hydraulic cement mortar, in the manner described for the rear part of the lock walls.

But the backing stone of the centre pier for 15 feet on each side of the railway track must have their beds and joints picked or scabbled, so that when laid the horizontal joints shall not exceed $\frac{5}{8}$ of an inch, and the vertical joints not to be more than one inch and a quarter.

The upper part of the abutments are to be recessed, curved, and otherwise adapted to the toe of the bridge, and they, as well as the centre pier, are to be carried up to the height shewn on a detailed plan to be furnished.

Coping stones to be at least 15 inches in depth, and of large dimensions; those immediately under the turntable to form a circle to support the track-way for the rollers. The pivot-stone to be not less that six feet square, and two feet depth of bed.

Below the centre pier a cluster of fender piles is to be driven at least 8 feet into the bottom, and well fastened together at top.

The upper wing walls and centre pier of the weir intended to regulate the water level below Lock No. 17, are to be extended, placed, and arranged to carry a fixed bridge for the Great Western Railway track.

To admit of building the masonry of these structures, the line of the railway, for some distance in this vicinity, will have to be changed for a time.

This change, as well as that of constructing the bridges, will form a separate contract, but the whole of the masonry is to be built by the contractor for the locks.

It is therefore to be clearly and distinctly understood:—

1ST.—That the contractor for this section of the canal, shall by the first day of April, 1875, have all the necessary stone prepared for the construction of the respective bridge abutments and piers above mentioned, and have full and satisfactory arrangements made for proceeding expeditiously with all this portion of the work at the time stated.

2ND.—That, nevertheless, no excavation shall be done, or any work commenced that would be at all likely to have the effect, or any tendency whatever to retard, obstruct, endanger, or in any way or shape injuriously interfere with the working of the existing line of the Great Western Railway, until after arrangements have been made to carry the traffic independent of the present line, nor until he (the Contractor) is officially notified to proceed with these special works.

3RD.—That the contractor's arrangements for urging forward these portions of the undertaking shall be such that within a period of four months from the day he is notified or directed to proceed with them, all the excavation, foundation work and masonry shall be fully completed, and the whole be ready in every respect to receive the superstructure of the bridges.

4TH.—It is further to be clearly and distinctly understood that the contractor for the masonry and section work, will not be allowed to occupy in any way the land required for the temporary change of the line of the Great Western Railway, nor the land necessary for service ground during the construction of the bridges above referred to, until after they (the bridges) are fully completed, and in use.

The contractor must construct dams wherever it may be necessary to keep out water during freshets, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, bailing, removing ice and snow, and every contingency, directly or indirectly connected with unwatering the lock and weir pits, and all other portions of the works during their progress and up to the full completion of the whole, and the satisfactory removal of all coffer dams, and other temporary works, must be embraced in the bulk sum stated in the tender for unwatering the works.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction, but detailed working drawings, arranged, modified and adapted to each lock and weir foundation, and for all such other parts of the structures as may be required, will be furnished as the work proceeds.

Wherever a public road crosses the line of the canal, the contractor must keep open, at his own cost and expense, convenient passing places during the progress of the works, and he shall be held responsible for keeping the crossings in such condition that they may be used safely.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be required for canal purposes by the Department of Public Works. He must also provide, furnish and deliver at his own cost all necessary materials, and procure all plant, tools, implements, derricks, machinery, and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

Tenders will not be considered, unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature and the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks, to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works on each section can be fully completed on or before the first day of April, 1877.

JOHN PAGE,

Chief Engineer of Public Works.

OTTAWA, 3rd January, 1874,

APPENDIX No. 5.

WELLAND CANAL.

SPECIFICATION of the Work on SECTION No. FOUR, for which tenders are invited.

This section is 3,250 feet in length, the boundaries and general line of which are marked out on the ground.

It includes the formation of the canal and banks for the distance above stated; the cutting of side ditches, drains, &c.; embankments for road approaches, and all excavation required to effect a change in the line of the Welland Railway, to the extent represented on the plan and to the gradients shown on the profile, or to such others as it may be necessary to adopt. It also embraces the construction of piers and abutments for two swing bridges—one for the Welland Railway and another for a road leading to St. Catharines; together with such other works as are herein described or the contractor may be called upon to execute.

The canal will be located as shown on the plans exhibited—the centre line corresponding nearly with that marked out on the ground; but the Department of Public Works reserves to itself the right of changing the whole, or any part of the line, as much as five hundred feet either to the right or left of that represented, and of altering the position of any, or all of the structures, five hundred feet, either upwards or downwards, from that indicated on the plan.

These changes it is to be clearly and distinctly understood may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made 100 feet wide at bottom, at the depth of 13 feet below the assumed water line, with side slopes both in excavation and embankment of two horizontal to one vertical.

Along each side of it a continuous towing path will be formed, 15 feet wide on top, and either raised or cut down, as may be required, to four feet over the water surface.

CLEARING, GRUBBING, MUCKING, &c.—From the space to be occupied by the canal, its banks and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brushwood of every description, must be burnt or otherwise removed, but so as not to do any damage to the adjacent lands.

All trees standing beyond the space mentioned, that by falling might injure the banks or obstruct navigation, are to be cut down, and removed if directed. All the clearing, grubbing, and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge before the work of excavation is commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth as may be directed for the entire space to be occupied by the bank, and the sods, soil or loose earth must be placed at such a distance from the banks as the officer in charge may direct. In all cases care must be taken to place the best, most solid and water-tight earth in that part of the banks adjoining the canal, and to place all coarse materials, or such as are permeable to water, at the outer extremity of the banks, or if required, to remove them altogether beyond the limits of the same.

The materials excavated from the reach, ditches, water courses, raceways, or bridge foundations when of a suitable kind must be hauled and placed wherever it is required to make up the banks of the canal, bridge approaches, or other embankments on the section within a distance of 1,000 feet, *the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given and lines marked out by the engineer.

The slopes both in cutting and embankment are, as already stated, to be *two* horizontal to *one* vertical; they must be made uniform and neatly trimmed, so as to present a fair outline corresponding to the line of the canal.

No ground to be broken within ten feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making an embankment, the borrowing pits must be made at such places and in such a manner either in the form of a ditch, or of such other shape and dimensions as may be required.

Where it is necessary to change the course of small streams, or for the purpose of carrying off surface water or other drainage, on any part or the whole of the section, the work is to be done by the contractor, and the material excavated must be hauled and used to make up the banks of the canal and bridge approaches, or other necessary works as may be directed.

When forming the banks of the canal, or *wherever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS,—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle beds impervious to water.

The diversion of the line of the Welland Railway, included in this section, is about one mile in length, and will occupy the position represented on the plan. It will for the most part be in embankment, the material for which will chiefly be obtained from borrowing pits, situated at different places alongside of the contemplated line.

It must be made fully 16 feet wide on top, at the height of sub-grade of the railway, and the side slopes throughout are to be one and a half horizontal to one vertical. The bank to be carried to such heights as will give the respective longitudinal inclinations

shown on the profile; the gradient on the new portion of the line nowhere to exceed 43½ feet to the mile; for 2,280 feet on the south side, and 1,000 feet on the north side of the centre of the canal crossing, the road bed will be level.

In all cases the slopes of the bank must be dressed and trimmed to the required angle, and the top made of an uniform height, corresponding to the lines and grades marked out by the officer in charge. The sides of the borrowing pits must also be trimmed off to such slopes as may be directed, and the whole of the earthwork connected with the new part of the line finished in a satisfactory manner.

All clearing, grubbing, &c., required for the railway diversion, must be executed in the manner described for a like class of work on the canal, and will be paid for under the same item.

The cutting of ditches, &c., for the railway will be paid for at the same rate, as other parts of the railway excavation.

In carrying on any or all of the works on this section, the operations must be conducted in such a manner as not to interfere in any way or shape with the railway traffic, as the contractor will be held strictly and legally liable to the proprietors of the railway, the public or individuals, for any damage, loss, accident, or detention which may be sustained through his acts, whether the same arise from oversight, neglect, or from a desire to proceed with the works expeditiously, or from any other act or cause whatever.

Fences are to be put up on both sides of the land occupied by the railway; they are to have sound, straight, well-shaped cedar posts, 8 feet long and 6 inches diameter at the small end, placed not more than 6 feet apart from centre to centre. They are to be let 3 feet 9 inches into holes bored in the ground for that purpose, and the earth around them must then be well packed, the posts properly lined, and suitable faces made to receive the boards. The latter to be in four continuous, uniform ranges of one-inch pine boards, of approved quality, 10, 8, 6, and 4-inch in width, and in lengths of 12 or 18 feet. They are to be placed at such heights, and distances, apart as may be directed, put on so as to break joint properly, and to be fastened with three-inch nails, two at every crossing of a post. A batten, 1 inch thick and 5 inches wide, must be fastened with nails 4 inches long over the boards opposite each post, and after the posts have been cut to an uniform height, a cap piece of 4 x 2 inches pine scantling must be well fastened with 4-inch nails, on the top of them.

This section, as previously stated, embraces the construction of piers and abutments for two swing bridges, at or near the places represented on the general plan. They are to be of masonry laid in hydraulic cement mortar, built chiefly in the form, dimensions and manner herein mentioned, or that may be subsequently required.

The centre and rest piers of the bridges are invariably to be parallel to the centre line of the canal, the former from 16 to 18 feet square, and the latter from 14 to 17 feet in width and 9 feet in thickness, and in all cases an arched culvert, varying from 6 to 8 feet in width and 8 feet in height, on a line ranging with that of the canal, will be made through the centre of them.

They are to be built on a foundation of timber and plank, the top of which must be at least one foot below canal bottom. On the lower course of the masonry, all around each of the centre piers there is to be an offset of about 6 inches, thence the sides are to be carried up vertical. The rest piers, at both ends of the bridges, are to have a batter of one in twelve on the up and down-stream sides, and of 1 in 24 on the ends.

The arch stones of the culverts are to be 21 inches deep, and dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth ($\frac{1}{4}$) of an inch. The bottom of the arch or waterway to be of dressed and properly jointed stones of a size that two of them will make up the width of the opening and at each end pass 15 inches under the wall, the second course to project one foot into the opening, and the third course 6 inches.

The face stones of the piers to be two and three feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full, and dressed so as to lay to joints one-fourth ($\frac{1}{4}$) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of each of the centre as well as the guide piers.

The heart of the wall in each case to be made up with flat-bedded stones, not less than 4 feet area of bed, and of the full height of the face stone; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the railway bridge to be 11½ feet thick at bottom, the sides of which are to be parallel to the canal, and the ends made to an angle corresponding to the oblique range of the bridge. They are to be of a like class of work, faced on both sides and ends as described for the centre and rest piers; made to a batter of one in twenty-four, and have the sharp points at the upper and lower ends taken off at right angles to the sides or ends to such an extent as may be directed. At four feet from the top of these piers, offsets on the front side are to be formed for the bridge seat.

For the common road crossing the piers to form the seat of the swing bridge will be 8½ feet wide at bottom, and be carried up with a similar class of masonry as described for the centre and rest piers; on both sides and ends the wall will be carried up to a batter of one in twenty-four.

The abutments are to be twenty feet or more distant from the bridge piers, and the foundation of them laid at 5 feet over canal bottom, or at such other level, either above or below that point, as circumstances may require. They are to be six feet or more in thickness, carried up to a batter of one in twelve on the face to water line, and made plumb in the rear to within 4 feet of top, thence the wall will diminish to the rear line of the coping, which will be 3 feet in width. The face work to be similar to that described for the piers, and the backing, of large-sized, well-shaped stone, laid level in full mortar, and properly bonded throughout the wall.

The centre piers, piers for seat, and rest of bridges, as well as the abutments, must all be built of an approved class of stone free from dry seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers, for the seats and rests of the bridges, and break joint properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full-bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top side must have a fair surface neatly boucharded, and where required the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed, to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones for a width of 4 feet is to be twenty-four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with tox wedged bolts 1½ inches diameter let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge, will be 10 inches in thickness at the centre of the road, curved on top so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward—one of which at each end of the bridge must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers, and finished with coping as indicated on the plans.

The walls above and below the abutments, for a distance of 40 feet or more, are to be of coursed masonry, arranged to wind gradually round to meet the line of the slope, on the respective sides. The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments they are to be laid either longitudinally or transversely, as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete, as may be directed.

The covering plank to be of pine, three inches thick, and must be fastened to the timbers with 1¼-inch white oak treenails 8 inches long.

SHEET PILES—of 4-inch pine plank are to be put in, or driven on all sides of the piers, if the officer in charge considers it necessary.

FENDERS—are to be constructed on both sides of the water-ways, extending for some distance above and below the bridge, as represented on general plan. They are to be formed by means of piles, caps and wale pieces, all of white oak timber. The piles to be not less than 12 inches diameter in the small end, driven from 6 to 10 feet into the bottom, and be about 6 feet apart; but at the cross ties and anchor timbers, two piles will be driven on the line of the fenders, and one about the middle of each tie timber. The caps to be formed of two pieces each 6 by 10 inches, arranged about 8 inches apart and checked obliquely to receive a dovetail formed on the heads of the piles, to each of which they will be secured with wrought iron screw-bolts, seven-eighths (⅞) of an inch diameter, having upset heads and cast iron bevelled washers, let flush into the outside cap pieces.

Immediately under the caps, the cross-ties will connect, with a dovetail, the outer couple of piles, and be farther secured by a thorough screw-bolt of seven-eighths (⅞) of an inch diameter.

The cross-ties to be mortised on the centre piles, and the ends extend to the outer side of the front cap pieces, and under them a waling timber of white oak, 6 x 10 inches is to be fastened to the piles with screw bolts of seven-eighths (⅞) of an inch diameter, with upset heads and washers, sunk flush, as described for the cap pieces.

The anchor timbers to be dovetailed between the piles, in like manner as stated for the cross-ties, and be let into the bank for such a distance as may be required, where they will be fastened to a cross timber.

For the protection of the bridge and piers, a cluster of ten or more piles will be driven in the centre of the canal, at a suitable distance above and below the range of the bridges when open; they are to be connected by means of thorough bolts, straps, &c., and stand fully 5 feet over water level.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement, and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry must be laid in mortar, made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportion as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather, in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction, and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of the frost..

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone, must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

The contractor must construct dams wherever it may be necessary to keep out water during freshets, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, baling, removing ice and snow, and every contingency, directly or indirectly connected with unwatering the works during their progress, and up to the full completion of the whole, and the satisfac-

tory removal of all coffer dams and other temporary works, must be embraced in the bulk sum stated in the tender for unwatering the works.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed working drawings, arranged, modified and adapted to each bridge site, and for all such other parts of the structures as may be required, will be furnished as the works proceed.

Before the present public road is cut away or in any way disturbed, the contractor must provide, at his own cost and expense, another and satisfactory means for the public travel to pass, either by the formation of another road, or the construction of a temporary bridge, or both, as may be found necessary; and he must put up and maintain all such fences as may be required for public safety.

It being clearly and distinctly understood that he (the contractor) shall be held legally liable and responsible for keeping everything connected with the crossing in such a condition that it can be safely used during the whole time that the bridge is in progress of construction.

MATERIALS, SERVICE GROUND, &C.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver at his own cost all necessary materials, and procure all plant, tools, implements, derricks, machinery, and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him), as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineers in charge.

Tenders will not be considered, unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works on the section can be fully completed on or before the first day of April, 1877.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 12TH MAY, 1875.

APPENDIX No. 6.

WELLAND CANAL.

SPECIFICATION of the Work to be done on Section No. SIX of the ENLARGEMENT.

On this section, the works for which tenders are invited consist chiefly of clay excavation, the construction of two abutments and a centre pier for a bridge.

The canal will be located as shown on the plans exhibited—the centre line corresponding nearly with that marked out on the ground; but the Department of Public Works reserves to itself the right of changing the whole, or any part of the line, as much as 500 feet either to the right or left of that represented, and of altering the position of any or all of the structures 500 feet either upwards or downwards of that indicated on the plan.

These changes it is to be clearly and distinctly understood may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made 100 feet wide at the bottom, at the depth of 13 feet below the assumed water line, with side slopes both in excavation and embankment of two horizontal to one vertical.

Along each side of it a continuous towing path will be formed, 15 feet wide on top, and either raised or cut down, as may be required, to four feet over the water surface.

CLEARING, GRUBBING, MUCKING, &c.—From the space to be occupied by the canal, its banks, basins and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brushwood of every description, must be burnt or otherwise removed, but so as not to do any damage to the adjacent lands.

All trees standing beyond the space mentioned that by falling might injure the banks or obstruct navigation, are to be cut down and removed, if directed. All the clearing, grubbing and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge before the work of excavation is commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth as may be directed for the entire space to be occupied by the bank, and the soil or loose earth deposited at such places as the officer in charge may direct. In all cases care must be taken to place the best, most solid and water-tight earth in that part of the banks adjoining the canal, and to place all coarse materials, or such as are permeable to water, at the outer extremity of the banks, or, if required, to remove them altogether beyond the limits of the same.

The materials excavated from the reach, water-courses, raceways or bridge foundation, when of a suitable kind, must be hauled and placed wherever it is required to make up the banks of the canal, or other embankments on the section within a distance of 1,000 feet, *the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given, and lines marked out by the engineer.

The slopes both in cutting and embankment are, as already stated, to be *two* horizontal to *one* vertical; they must be made uniform and neatly trimmed, and so as to present a fair outline corresponding to the line of the canal.

No ground to be broken within ten feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making an embankment, the borrowing pits must be made at such places and in such a manner either in the form of a ditch, or of such other shape and dimensions as may be required.

Where it is necessary to change the course of small streams, or for the purpose of carrying off surface water or other drainage, on any part or the whole of the section, the work is to be done by the contractor, and the material excavated must be hauled and used to make up the banks of the canal, or other necessary works as may be directed.

In the banks adjoining basins, openings of such dimensions, and in such a position as required, are to be left for the free ingress and egress of the water.

Their sides are to be formed either of rubble masonry of a substantial class, laid in hydraulic cement mortar, or of cribwork filled with stone, as may be hereinafter determined.

In cases where the depth of excavation exceeds 17 feet, the banks must be cut down to that height, for the width of the towing path, the top of which is to be made with an inclination outwards to a ditch formed in the rear, or at the toe of the slope of the adjoining bank.

The ditch to be of such a width, depth and inclination as will convey the surface water to such places as it can be disposed of in a satisfactory manner.

Where it may be necessary to spoil material removed from a cut, the foot of the spoil bank slopes must be at least 20 feet back from the edge of the cut, and the upper surface made of an uniform height, with an inclination outwards of 1 in 16, and side slopes of 2 to 1.

When forming the banks of the canal, or those of the basins, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or wagons, and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed.

They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle beds impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "Earth" and "Rock," the former to embrace all kinds of materials found in the cuttings or borrowing pits, except absolutely connected "Quarry Rock," and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing paths, and completing everything connected with the excavation of the section, in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been completed and executed the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

ON THIS SECTION the abutments and centre pier for a bridge in line of the road from St. Catharines to Niagara, are to be constructed of masonry, in the position indicated on the general plan.

The centre pier of the bridge to be built either in three separate blocks, or in one continuous range, as may be subsequently determined. Both the abutments and pier to be placed on a foundation of timber and plank, laid so that the top of the plank shall be at least 1 foot below the bottom of the canal.

The face stone of the centre pier to be 2 and 3 feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full, and dressed so as to lay to joints of ⅜ of an inch; and the face picked or scabbled so as to have a batter of 1 in 24.

The heart of the wall to be made up with flat-bedded stones not less than 3 feet area of bed, and of the full height of the face stone; their beds and joints must be scabbled, or picked, if necessary, so that when laid the horizontal joints shall not exceed ⅝ of an inch, and the vertical joints not be more than one inch and a quarter.

The abutments to be of coursed work carried up to a batter of 1 in 12; face stone to be at least 20 and 30 inches depth of bed in the alternate courses, and not less than 2 feet long in line of wall, with headers in every course 3½ feet depth of bed, and not more than 9 feet apart.

Their faces must be dressed and the arrises kept good, the upper and lower beds made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face.

The whole to be dressed so that, when laid, the horizontal and vertical joints shall not exceed $\frac{3}{8}$ of an inch mortar joints.

BACKING—to be of stones not less than 6 inches thick and 3 feet area of bed, laid level in full mortar, and properly bonded throughout the wall.

The lower beds of the stone, if necessary, must be picked off so as to insure a fair bearing on the course below, vertical joints to be well grouted up, and everything done to make substantial work.

All these walls must be built of an approved class of stone, laid in hydraulic cement mortar, properly bonded throughout, and have all their vertical joints well grouted as the work proceeds.

The abutments are to be recessed, curved and otherwise adapted for the toe of the bridge, and they, as well as the centre pier, are to be carried up to the height shewn on a detailed plan to be furnished.

Coping stones to be at least 15 inches in depth, and of large dimensions; those immediately under the turntable to form a circle to support the track-way for the rollers. The pivot-stone to be not less than 6 feet square and 2 feet depth of bed.

On both sides and ends of the centre pier, a close range of piles is to be driven down to fully 6 feet under the canal bottom, and their tops to be at least 6 feet over the surface water line; they are to be properly capped, and otherwise satisfactorily secured at top.

Before the present public road is cut away, or in any way disturbed, the contractor must provide, at his own cost and expense, another and satisfactory means for the public travel to pass, either by the formation of another road, or the construction of a temporary bridge, or both, as may be found necessary; and he must put up and maintain all such fences as may be required for public safety.

It being clearly and distinctly understood that he (the contractor) shall be held legally liable and responsible for keeping everything connected with the crossing in such a condition that it can be safely used during the whole time that the bridge is in progress of construction.

The contractor must construct dams wherever it may be necessary to keep out water during freshets, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, baling, removing ice and snow, and every contingency, directly or indirectly connected with unwatering the works during their progress and up to the full completion of the whole, and the satisfactory removal of all coffer dams, and other temporary works must be embraced in the bulk sum stated in the tender for unwatering the works.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction; but detailed working drawings, arranged, modified and adapted to the foundation, and for all such other parts of the structure as may be required, will be furnished as the work proceeds.

Wherever a public road crosses the line of the canal at any place other than that above mentioned, the contractor must keep open, at his own cost and expense, convenient passing places during the progress of the works, and he shall be held responsible for keeping the crossings in such condition that they may be used safely.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

Tenders will not be considered, unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such manner as to fully satisfy the Department of Public Works that the whole of the works of the section can be fully completed on or before the first day of April, 1877.

JOHN PAGE,

Chief Engineer of Public Works.

OTTAWA, 3rd January, 1874.

APPENDIX No. 7.

WELLAND CANAL.

GENERAL SPECIFICATION for the Enlarged Canal between THOROLD and PORT DALHOUSIE.

The canal will, for the most part, be located as shown on the general plan exhibited—the centre line corresponding nearly with that marked out on the ground, but the Department of Public Works reserves to itself the right of changing the whole or any part of the line, as much as five hundred feet, either to the right or to the left, of that represented, and of altering the position of any, or all of the structures, five hundred feet, either upwards or downwards, of that indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made 100 feet wide at bottom, with a depth of 13 feet below the assumed water line; side slopes to be 2 horizontal to 1 vertical, in clay or earth excavation; and in rock, the sides are to have an inclination of $\frac{1}{4}$ to 1.

A continuous towing path is to be formed on both sides of the canal, 15 feet wide on top, and 4 feet over the water surface, increasing where the ascent is made to the next reach, at the rate of about 1 in 15.

CLEARING, GRUBBING, MUCKING, &c.—From the space to be occupied by the canal, its banks, basins and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brush of every description, must be burnt, or otherwise removed, but so as not to do any damage to the adjacent lands.

All trees standing beyond the space mentioned, that by falling might injure the banks, or obstruct navigation, are to be cut down and removed, if directed. All the clearing, grubbing and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge, before the works of excavation are commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth, as may be directed, for the entire space to be occupied by the bank; the sod or loose earth must be placed at such a distance from the banks as the officer in charge may require; and in all cases, when making up a bank, care must be taken to place the best, most solid, and water-tight earth in that part of the banks adjoining the canal, and to place all coarse materials, or such as are permeable to water, in the outer extremity of the banks, or if required to remove them altogether beyond the limits of the same.

The material excavated from the different reaches, when of a suitable kind, must be hauled and placed wherever it is required to make up either the banks of the canal, or the basins, or embankments behind the locks and weirs, within a distance of 1,000 *feet; the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given and lines marked out by the engineer.

The slopes, both in cutting and embankments, are, as already stated, to be *two* horizontal to *one* vertical, made uniform, and trimmed neatly, and so as to present a fair outline corresponding to the line of the canal.

No ground to be broken within 10 feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making up an embankment, the borrowing pits will generally be from a place which is to form part of a basin; but when a borrowing pit is outside of a bank, where there is no basin, the excavation must be made either in the form of a ditch, or of such other shape and dimensions as may be directed.

In the banks adjoining basins, openings of such dimensions, and in such a position as required, are to be left for the free ingress and egress of the water.

Their sides are to be formed either of rubble masonry, of a substantial class, laid in hydraulic cement mortar; or of cribwork, filled with stone, as may be hereafter determined.

When the basin is large, or circumstances may require, there are to be either two separate openings through a bank, or a large one divided by a centre pier of coursed masonry, built of large, flat-bedded stones, and carried to a like height as the abutments, so as to form a bearing for the bridge stringers.

In cases where the depth of excavation exceeds 17 feet, the banks must be cut down to that height, for the width of the towing path, together with such a space for ditches as may be required.

Where it may be necessary to spoil material removed from a cut the foot of the spoil bank slopes must be at least 20 feet back from the edge of the cut, and their upper surface made of an uniform height, with an inclination outwards of 1 in 16, and side slopes of 2 to 1.

When forming the banks of the canal, or those of the basins, or embankments in rear of the locks and weirs, or wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time; and if the work be done at a dry season of the year, water must be thrown over each layer, to assist in consolidating the material.

PUDDLE BEDS,—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed.

They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "Earth" and "Rock;" the former to embrace all kinds of materials found in the cuttings or borrowings pits, except absolutely connected "Quarry Rock" and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing path, and completing everything connected with the excavation of the section, in a workmanlike and satisfactory manner, agreably to the foregoing specifications.

But as the price, per cubic yard, for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner, that when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

LOCKS.—The locks are to be 270 feet in length between the gate quoins and 45 feet in width between the side walls, at the level of the lower reach. They are to be constructed of dressed stone masonry laid throughout in hydraulic cement mortar, and placed on foundations prepared as hereinafter described.

The pits excavated for them are to be made of suitable dimensions to admit the side and wing walls, and to correspond with such lines as will be marked out on the ground by the officer in charge.

In rock the sides of the cut are to be made perpendicular, and a space of one foot left in rear of the walls for concrete; and in clay cutting such slopes are to be formed as may be required for stability.

The bottom must, in all cases, be trimmed smooth and level, at a proper height, to give a fair and uniform bearing to the foundation timbers, or base of the walls.

The material excavated from the lock pits, unless otherwise directed, must be spoiled at the north-west end of the section, in like manner as that described to be taken from the reaches, adjoining banks, and other portions of the works.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where a lock is to be built, the walls will be commenced upon it, without an artificial foundation; but if the rock be unsound, the fissures in it numerous, the strata thin or irregular, a floor of pine timber, covered with 3-inch plank, will be laid at a height to form a bearing surface for the walls, and a similar course will be adopted where the foundation is of earth or clay.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length, to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

When on clay they are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed, and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through, and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &c.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must, in all cases, be made of the best materials for that purpose which can be obtained in that vicinity; cut, mixed prepared, and laid as directed by the officer in charge.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally, 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inches diameter, two in each end of a plank, and on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 3 inches deep, is to be cut into the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½) diameter, have upset heads, and be well ragged at the points.

Where the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATERS.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock, 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts 1¼ inches diameter, placed not more than 10 feet apart.

Stop-waters, similar to those above described, are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than those occupied by the platforms, there are to be timbers, 12 inches square, laid 6 inches apart, also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, 1¼ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The locks are to be from 12 to 14 feet lift, and the side walls carried up to 2 feet over the surface water level of the upper reach, with which they are connected. The chamber walls are to be 10 feet wide at bottom, with counterforts in rear, 6 feet long in line of wall, and 3 feet projection, placed not more than 12 feet apart; the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping; the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound and durable stones; those which form the face work must be free from drys, seams or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed $\frac{3}{8}$ of an inch.

CUT STONE—to be neatly dressed and boucharded, made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints, in all cases, kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than 2 and 3 feet depth of bed on the alternate courses. In each course must be headers of at least two feet length of face and $4\frac{1}{2}$ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers, in the alternate courses, must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{4}$ times their height; and in all cases the tail of a header must have a width of $\frac{2}{3}$ the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least $4\frac{1}{2}$ feet face and $5\frac{1}{2}$ feet depth of bed; the latter $5\frac{1}{2}$ feet face and $4\frac{1}{2}$ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also $4\frac{1}{2}$ by $5\frac{1}{2}$ feet, and $5\frac{1}{2}$ by $4\frac{1}{2}$ feet, laid alternately out-bond and in-bond, bevelled, as shewn on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain-wells in the positions indicated on the plan; each well will be 2 feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening, and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face-walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face, and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed $\frac{3}{8}$ of an inch.

BACKING—to consist generally of large, well-shaped stones, not less than 6 inches in thickness, and 4 feet area of bed, laid level in full mortar beds and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depths does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick ; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stone must, in all cases, be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES,—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls ; except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces will extend over the buttresses for the chain-wells, for the arrangement of which as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top, and two feet depth of bed.

The lower bed and joints of each stone must be kept full ; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock ; it will be 7 feet wide at bottom, 3 feet on top, built of coursed rubble masonry, and covered with suitable coping.

When locks are wholly or in part in rock-cutting, the space between the back of the walls and rock must be made up of concrete, well mixed and pounded, and carried up simultaneously with the walls.

CONCRETE,—when used, must consist of an approved quality of stone, broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement, and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar, made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement ; or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED--in rear of the lock walls to be 3 feet in width carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at back of the walls, made up in the manner already described, are to be 25 feet in width, and have a declivity of 6 inches outwards from the lock.

RUBBLE WALLS,—forming the extension of the wings at the head and foot of the locks, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over and with each other, and laid in cement mortar for such a distance below the lock as may be directed.

These walls are to be built to such lines as will form a suitable connection between the locks and retaining walls, or the slope walls as the case may be; and the face of the stones are to be hammered, or scabbled to such batters, or lines as may be required to adapt them to the positions they are to occupy in the work.

On Section No. 8, a syphon culvert will be built, to pass the waters of the "Ten Mile Creek," the foundation of which must be sunk to 10½ feet under the bottom line, and the material, when of a suitable class, placed so as to form embankments in the vicinity, or where directed.

The structure will be of masonry, built with two arched openings, each 8 feet in width. The foundation will be formed of pine timber 12 inches square, laid 6 inches apart—the spaces between which must be filled with puddle, well rammed, or concrete if directed.

Floor to be of 3-inch, well-jointed pine plank, laid so as to break joints every 3 feet in width, and be secured with 7-inch pressed spikes, two in each end of a plank and one on alternate sides at every crossing of a timber.

A course of 3-inch sheet piles, sunk 4 feet below the floor timbers, is to be placed at each end, for which trenches about 2½ feet in width are to be dug, and afterwards well filled with the best description of puddle.

The heads of the piles are to be secured to the foundation timber by 7-inch pressed spikes, two in each plank.

The face stones of the side walls or abutments, to be at least 2 feet in width of bed, with headers not more than 8 feet apart—centre pier to be 2½ feet in width, made up of stones the full thickness—suitable springers to be prepared, and the beds of the arch stones, 20 inches in depth, are to radiate truly.

The faces of the abutments, centre pier and soffit of the arches, are to be dressed; the joints and the beds made so as not to exceed ⅜ of an inch mortar joints; the breasts and sides of the walls are to be of a like class of masonry as the abutments; the wings and parapet walls to have dressed beds and joints, and a "rock face."

Coping to be 3 feet wide, 12 inches thick, in lengths of at least 3 feet; top to be neatly boucharded; beds and ends to be dressed so as to lay to mortar joints of ¼ of an inch. The abutment walls and spandrel filling to be carried up to within one foot of the crown of the arches.

A puddle bed 2 feet in depth and for the entire width of the canal and embankments, is to be laid over the culvert.

Detailed plans of the structure will be furnished by the engineer.

At the lower end of Lock No. 13, on Section No. 10, there will be a road crossing, to provide for which, walls, in continuation of those of the lock, but of less height, will be built to form bridge abutments.

They will rest on a foundation of timber, and have sheet piles at the toe of the walls, and will be of a like class of masonry as described for the chamber walls of the locks, but with certain changes and modifications, the details of which will be furnished.

In line with the swing bridge, two abutments will be built to receive the superstructure of a fixed bridge over the channel connecting the reservoirs.

The superstructure, fixtures and machinery required for working the swing bridge will, however, be made a separate contract; but all masonry required for these bridges is to be done by the contractor for the locks.

Near the upper end of Section No. 11, a culvert is to be constructed under the canal for a public road; the foundation of which will be about 22 feet under the bottom line of the canal, and the crown of the road 18 feet under the same line. The structure will be of masonry—roadway 14 feet in width and 14 feet high, to the underside of the arch.

The foundation for the abutments and wings, to consist of a bed of concrete of such a depth as may be directed, or be formed of large, flat-bedded stones, or otherwise prepared as may be required.

Up to within 12 inches of the road surfaces, the abutments and wings are to be of rubble masonry, built of large, flat-bedded stones laid throughout in full mortar beds.

The face stones of the abutments and wings, over the point above mentioned, are to be 2 and 3 feet width of bed in the alternate courses, with headers in each course 4½ feet long, placed not more than 9 feet apart.

The arch stones are to be 2 feet in depth, and must have their beds dressed so as to radiate truly from the centre of the arch. Suitable springers must be prepared, and the outer ring stones at both ends neatly cut.

The face of the abutments and soffit of the arch are to be dressed, the beds and ends kept full, and laid throughout so as not to exceed ¼ of an inch mortar joints.

Wings and parapet walls to have dressed beds and joints, with a "rock face."

Coping to be 3½ feet wide, and 12 inches thick, in lengths of at least 3 feet; top to be neatly boucharded; beds and end joints dressed so as to lay to mortar joints of ¼ of an inch.

The abutment walls to be carried up to within 1 foot of the crown of the arch, and the whole thoroughly flushed on the back, levelled up or rounded to a moderately smooth surface with cement mortar as may be directed.

A puddle bed 2 feet in depth for the entire width of the canal and embankments on both sides is to be laid over the culvert.

The whole of the masonry of this culvert must be of the very best description of work, laid throughout in hydraulic cement mortar, the joints to be properly grouted as the building proceeds, and the whole executed as described for the lock masonry.

Retaining walls of dry rubble masonry to extend out from the end of the wing walls for such distance as may be required.

Detailed plans of the structure, &c., will be furnished by the engineer.

Regulating Weirs,—arranged as indicated on the general plan, or in such other positions as may be required, are to be constructed as hereinafter described.

The space excavated for the weir to be sufficiently large to admit the side walls, and be at least 5 feet below the surface level of the lower reach.

Foundation to be formed of pine timber, 12 inches square, laid 12 inches apart—the spaces to be filled with a good description of puddle, well beaten down; the floor to be of 3-inch pine plank, treenailed to the timbers, and a second course of plank, 2 inches in thickness, is to be laid between the wings below the breast wall. There are to be three ranges of sheet piles across the foundation; one above and another below the breast wall, and the third at the lower end of the wings.

The masonry of the wings to be of rock work, face stones to be 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course, dressed and laid so that the end joints shall not exceed ⅜ of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work, laid to a batter of about 4 inches to the foot rise.

There are to be six sluice-ways through this wall, each 4 feet wide and 4 feet high, the sides of which are to be dressed smooth; sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

Breast wall coping to be dressed 4 feet wide on top, increasing in width downwards; the stones are to be well dowelled together. Wing coping to be 3½ feet wide, to have the beds and joints kept full throughout, and top neatly boucharded.

BACKING—to be of a like class of work as that described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared in the manner already stated.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction; but detailed working drawings, arranged, modified and adapted to each lock and weir foundation, and for all such other parts of the structures as may be required, will be furnished as the work proceeds.

Wherever a public road crosses the line of the canal, the contractor must keep open, at his own cost and expense, convenient passing places during the progress of the works, and he shall be held responsible for keeping the crossings in such condition that they can be used safely.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish, and deliver at his own cost all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

The party whose tender may be accepted shall be subject to all the clauses and conditions in regard to payments, retained percentage, and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada, and to such other special conditions as the nature of the works may, in the opinion of the Minister of Public Works, seem to demand.

The works are to be commenced immediately after the person or persons whose "Tenders" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works on each section shall be fully completed on or before the 1st day of August, 1876.

JOHN PAGE,
Chief Engineer Public Works.

OTTAWA, 18th December, 1872.

APPENDIX No. 8.

WELLAND CANAL.

SPECIFICATION of the work to be done on SECTION No. TWELVE of the Enlargement.

This section is about 2,115 feet in length, the boundaries of which are marked out on the grounds. It includes all the works connected with the formation of the canal and banks, where necessary, for the distance above stated; the excavation of lock and weir pits, embankment for basins, &c., &c.

It also embraces the construction of two lift locks, two regulating weirs, and forming a new line of about one mile and a half in length for the diversion of the Great Western Railway; upon which a culvert, or tunnel, (650 feet long) to pass the track, will be constructed under the canal; together with such other structures as are herein described, or the contractor may be called upon to execute.

The canal will, for the most part, be located as shown on the general plan exhibited —the centre line corresponding nearly with that marked out on the ground, but the Department of Public Works reserves to itself the right of changing the whole, or any part of the line, as much as two hundred feet, either to the right or to the left of that represented, and of altering the position of any, or all of the structures, three hundred feet, either upwards or downwards, from that indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made 100 feet wide at bottom, with a depth of 13 feet below the assumed water line; side slopes to be 2 horizontal to 1 vertical, in clay or earth excavation; and in rock, the sides are to have an inclination of $\frac{1}{4}$ to 1.

A continuous towing path is to be formed on both sides of the canal, 15 feet wide on top and 4 feet over the water surface, increasing where the ascent is made to the next reach, at the rate of about 1 in 15.

CLEARING, GRUBBING, MUCKING, &c.—From the space to be occupied by the canal, its banks basins and side ditches, all trees, bushes and roots are to be cut and grubbed, which, together with all logs and brush of every description, must be burnt, or otherwise removed, but so as not to do any damage to the adjacent lands.

All trees standing beyond the space mentioned, that by falling might injure the banks or obstruct navigation, are to be cut down and removed, if directed. All the clearing, grubbing, and removal of brush, logs, &c., must be completed to the satisfaction of the officer in charge before the work of excavation is commenced.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a depth as may be directed, for the entire space to be occupied by the bank; the sod or loose earth must be placed at such a distance from the banks as the officer in charge may require; and in all cases, when making up a bank, care must be taken to place the best, most solid, and water-tight earth in that part of the banks adjoining the canal, and to place all coarse materials, or such as are permeable to water, in the outer extremity of the banks, or, if required, to move them altogether beyond the limits of the same.

The material excavated from the different reaches, water-courses, raceways, lock and weir-pits, when of a suitable kind, must be hauled and placed wherever it is required to make up either the banks of the canal, or the basins or embankments behind the locks and weirs, within a distance of 1,000 *feet; the cost of which must be embraced in the price tendered for excavation.* The contractor in proceeding with the work must invariably be guided by the levels given and lines marked out by the engineer.

The slopes, both in cutting and embankment, are, as already stated, to be *two* horizontal to *one* vertical, made uniform and trimmed neatly, so as to present a fair outline, corresponding to the line of the canal.

No ground to be broken within ten feet of the outer slope of any bank, and when it is necessary to obtain earth for the purpose of making up an embankment, the borrowing pits will generally be at a place which is to form part of basin; but when a borrowing pit is outside of a bank, where there is no basin, the excavation must be made either in the form of a ditch or of such other shape and dimensions as may be required.

Where it is necessary to change the course of small streams or make channels for the purpose of carrying off surface water or other drainage, on any part or the whole of a section, the work is to be done by the contractor, and the material excavated must be hauled and used to make up the banks of the canal or basins, as may be directed.

In the banks adjoining basins, openings of such dimensions, and in such a position as required, are to be left for the free ingress and egress of the water. Their sides are to be formed either of rubble masonry, of a substantial class, laid in hydraulic cement mortar, or of crib work, filled with stone, as may be hereinafter determined.

When the basin is large, or circumstances may require, there are to be either separate openings through a bank or a large one, divided by piers of coursed masonry, built of large flat-bedded stones, carried to a like height as the abutments, to form a bearing for the bridge stringers.

In cases where the depth of excavation exceeds 17 feet, the banks must be cut down to that height, for the width of the towing path, together with such a space for ditches as may be required.

Where it may be necessary to spoil material removed from a cut, the foot of the spoil bank slopes must be at least 20 feet back from the edge of the cut, and the upper surface of them made of an uniform height, with an inclination outwards of 1 in 16, and side slopes of 2 to 1.

When forming the banks of the canal, or of the basins or embankments in rear of the locks and weirs, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer, to assist in consolidating the material.

PUDDLE BEDS—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely "Earth" and "Rock;" the former to embrace all kinds of materials found in the cuttings or borrowing pits, except absolutely connected "Quarry Rock" and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing path, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price, per cubic yard, for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

LOCKS.—The locks are to be 270 feet in length between the gate quoins and 45 feet in width between the side walls, at the level of the lower reach. They are to be constructed of dressed stone masonry laid throughout in hydraulic cement mortar, and placed on foundation prepared as hereinafter described.

The pits excavated for them are to be made of suitable dimensions to admit the side and wing walls, and to correspond with such lines as will be marked out on the ground by the officer in charge.

In rock the sides of the cut are to be made perpendicular, and a space of one foot left in the rear of the walls for concrete; and in clay-cutting such slopes are to be formed as may be required for stability.

The bottom must, in all cases, be trimmed smooth and level, at a proper height, to give a fair and uniform bearing to the foundation timbers or base of the walls.

The material excavated from the lock pits, when of a suitable kind, must be used for the purpose of making up the banks, hauled and placed in like manner as described for that taken from the reaches and other portions of the work.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where a lock is to be built, the walls will be commenced upon it, without an artificial foundation; but if the rock be unsound, the fissures in it numerous, the strata thin or irregular, a floor of pine timber, covered with 3-inch plank, will be laid at a height to form a bearing surface for the walls, and a similar course will be adopted where the foundation is of earth or clay.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

When on clay they are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed, and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers before being laid must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as the other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through, and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &C.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best material for that purpose which can be obtained in that vicinity; cut, mixed, prepared and laid as directed by the officer in charge.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inches diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shewn on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 by 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep is to be cut in the lower edge of the mitre sills to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons, and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated in boiling tar, is to be placed in the cheek formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one and a half inches ($1\frac{1}{2}$) diameter, have upset heads, and be well ragged at the points.

Where the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATERS.—Where the rock underneath is sound, instead of sheet piles, at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock, 4 inches or more in depth, and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, $1\frac{1}{4}$ inches diameter, placed not more than 10 feet apart.

Stop-waters, similar to those above described, are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than those occupied by the platforms, there are to be timbers, 12 inches square, laid 6 inches apart, also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, $1\frac{1}{4}$ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The locks are to be from 12 to 14 feet lift, and the side walls carried up to 2 feet over the surface water level of the upper reach with which they are connected. The chamber walls are to be 10 feet wide at bottom with counterforts in rear, 6 feet long in line of wall, and three feet projection, placed not more than 12 feet apart—the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping; and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound, and durable stones; those which form the face work must be free from drys, seams, or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths ($\frac{3}{16}$) of an inch.

The chamber walls between the points above mentioned are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

CUT STONES—to be neatly dressed and boucharded; made square, bevelled or otherwise suited to the position they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of the beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than two or three feet depth of bed on the alternate courses. In each course must be headers, of at least two feet length of face, and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least 1½ times their height, and the headers 2¼ times their height; and in all cases the tail of a header must have a width of ⅔ the length of its face.

HOLLOW QUOINS,—to be alternately headers and stretchers, the former at least 4½ feet face and 5½ feet depth of bed; the latter 5½ feet face and 4½ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS,—to be also 4½ by 5½ feet, and 5½ by 4½ feet laid alternately out-bond and in-bond, bevelled as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN-WELLS AND MAN-HOLES.—There are to to be eight chain-wells in the positions indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK,—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face in line of

wall. In every course there are to be headers of at least 20 inches length of face, and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

BACKING—to consist generally of well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off to insure an uniform and equal bearing on the couse below; no pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls; except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain-wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least $6\frac{1}{2}$ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed one-fourth ($\frac{1}{4}$) of an inch.

A dowel, 4 inches long, of $1\frac{1}{2}$-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be 7 feet wide at bottom, 3 feet on top, built of coursed masonry and covered with suitable coping.

When locks are wholly or in part in rock cutting, the space between the back of the walls and rock must be made up of concrete, well mixed and pounded, and carried up simultaneously with the walls.

CONCRETE—where used, must consist of an approved quality of stone broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the directions and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well tempered rich mortar, or by using about one and a half (1½) of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be three feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered properly, cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds, where required at other places, are to be made in a similar way, and of such dimensions as may be directed.

The embankments at the back of the walls, made up in the manner already described, are to be 25 feet in width, and have a declivity of six inches outwards from the lock.

RUBBLE WALLS—forming the extension of the wings at the head and foot of the locks, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over and with each other, and laid in cement mortar for such a distance below the lock as may be directed.

The walls are to be built to such lines as will form a suitable connection between the locks, the slope walls, inner face of the banks, or retaining walls, as the case may be; and the face of the stones are to be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

REGULATING WEIRS—arranged as indicated on the general plans, or in such other positions as may be required, are to be constructed as herein described. The pits for them are to be sunk at least 5 feet below the surface level of the lower reach, and made sufficiently large to admit the side walls. The material excavated from the pits, as well as from the raceway or water-courses leading to or from them is to be used for forming banks where required, and must be hauled and placed in the manner previously described.

The bottom of the pit must be trimmed to a level and uniform surface to receive the foundation timbers, which are to be of pine, 12 inches square, laid 12 inches apart, and to rest on mud sills placed within the line of the side walls and on the bottom throughout their entire length. The spaces between the timber to be filled with a good description of puddle, well beaten down; floor to be of 3-inch pine plank, laid to break joint every 3 feet in width of planking, and be well fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inches diameter; two in each end of a plank, and one on alternate sides at every crossing of a timber. Below the breast wall and between the wings, a second course of plank, 2 inches in thickness, is to be laid and fastened as may be directed.

There are to be three ranges of sheet piles across the foundation; one above and another below the breast wall, and the third at the lower end of the wings; they are all to be of like dimensions, placed and secured as stated for those in the lock foundations.

MASONRY—walls are to be built in the positions and be of the respective dimensions represented in the general plan; throughout they must consist of sound and durable stones, free from seams and other defects, laid in full mortar, on their natural beds.

The wings are to be of "rock work," carried up to a batter of 1 in 12, face 1[illegible] inches, and 2 feet depth of bed in the alternate courses, with headers $3\frac{1}{2}$ feet depth of bed and not more than 10 feet apart in every course, dressed and laid so that the beds and end joints shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course $4\frac{1}{2}$ feet deep, and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed $\frac{1}{4}$ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work, laid to a batter of about 4 inches to the foot rise.

There are to be six sluice-ways through this wall, each 4 feet wide and 4 feet high, the sides of which are to be dressed smooth—sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

BREAST WALL COPING—to be 4 feet wide on top, increasing in width downwards to the batter of the wall; the lower bed and joints must be kept full throughout, the top dressed fair, and have a declivity of 1 inch towards the up-stream side.

A centre pier is to be carried up above the breast wall to form a bearing for a bridge; it is to be 5½ feet wide at bottom—batter on both sides so as to be 4 feet wide at top, and built in courses corresponding in height to those of the breast wall, and of such a width of bed that two stones will make up the thickness of the pier, and have headers, not more than 9 feet apart, passing entirely through the wall.

The coping to be dressed on top, and of the full width of the wall. Offsets on the different courses of the lower wings to be made from 5 feet over the level of the lower reach, as represented on plan. Wing coping to be at least 12 inches high, 3½ feet wide, with beds and joints kept full throughout, and top neatly boucharded.

In addition to a range of sheet piles to be placed in line of the breast wall, a counterfort of masonry 4 feet thick and at least 7 feet in length will be carried up in rear of each wing, to the height of the water level of the upper reach.

BACKING—to be of a like class of stone, and laid in like manner, as described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared as stated for other portions of the works.

A puddle bed 3 feet in width is to be carried up in rear of the side or wing walls to the full height of the water level of the upper reach. The material used for this purpose, as well as for the puddle between the foundation timbers, and for the sheet pile trenches, must be of the best and most suitable kind that can be obtained on the section or in the vicinity of the work.

DIVERSION OF THE GREAT WESTERN RAILWAY LINE.

To guard against interruption to the railway, or to the canal in this vicinity, arrangements have been made by which the track of the former shall pass under the latter at a point above the eighteenth lock.

To enable this to be done, the new part of the railway will leave the present one a short distance west of the Valley of the Ten Mile Creek, and continue on such lines as will lead through a culvert built on a like curved range, obliquely to the canal, thence it takes a course inclining toward the present track, and gradually touches the existing boundary line of the railway property at about a mile and a-half (measured along the new line) from the western point of divergence.

The present boundary of the railway property at both ends of the new line is about the extent of this kind of work embraced in the section.

To the west of the culvert the inclination will be a little over 21 feet to the mile; through the culvert the road bed will be nearly level, and to the eastward of it the gradient for some distance will be about 42 feet to the mile.

In cuttings, the bottom will be made 24 feet wide at the level of sub-grade, and the top of embankments at the same level is to be made 18 feet wide. The side slopes in both excavation and embankment are to be one and a-half horizontal to one vertical, except in rock-cutting where they are to be made a quarter to one.

All the material excavated from the cuttings for the new part of the railway, beyond that required to form embankments on the line, or for making up banks around the basins, or for other necessary purposes, must be deposited near the west end of the new line in the Valley of the Ten Mile Creek, or at such other places in that vicinity as may be pointed out to the contractor. Spoil banks, wherever formed, must invariably be made of the height required, have such an inclination on top, and the sides trimmed to such slopes as may be directed.

In the cuttings for the new line of railway there is reason to believe that rock will be met, especially towards the eastern end of it; wherever this occurs a berm will be made on the top of the rock, of such a width as will admit of that part of the slope over it forming a continuous line with those parts of the banks on both sides.

In case of springs being found in the cuttings, or of water oozing out of the banks, under drains must be formed from all such places to the side ditches, either directly or otherwise, as circumstances may require. The drains must be sunk below the frost line, be made of the extent, and run in the direction that will be most likely to effect the object. They are to be made as narrow as possible, and in the bottom a few small cedar poles should be placed, and over them 20 to 24 inches of coarse gravel, or small broken stone, over which a layer of brush should be spread before the trench is filled up.

After the slopes have been trimmed to the required angle, and the surface of those forming the sides of the cut have been prepared in the best manner, they are to be sodded, if so directed; the sods to be of an approved description, properly laid and fastened with such a number of suitable pins, well driven into the slopes, as may be considered necessary to effect the object.

On the completion of the cuttings, and the formation of the road-bed to the gradients stated, channels to carry off the surface water are to be made along each side of the bottom of the slopes. They are to be faced or lined with a durable class of well-shaped stones, from 8 to 10 inches in depth, pitched, laid close together, and be properly bedded in sand, well pounded, and of a depth of at least six inches. The upper surface of them to be concave from 6 to 18 inches, transversely, straight on the sides, and have a width varying from 2½ to 5 feet, or be of such other depth and width as it may be found necessary to adopt.

At every 150 feet in length, or where it may be considered necessary, a cross-wall 2 feet thick, laid in hydraulic cement mortar, is to be built the full width of the channel; the foundations of the walls are to be at least 3 feet lower than the bottom centre line of the channel at the respective places.

If the nature of the material renders it necessary to construct a retaining wall along the toe on one or both sides of the cutting, the work must be done, and a well-bedded properly-jointed coping, 2½ feet in width and at least 10 inches in thickness, put upon it. The whole of the masonry connected with the wall will be classed and paid for under the item of "Rubble Work."

Where the drainage has an outlet through culverts under the present track, such as can be rendered available, the drainage from the south side is to be led towards it by means of a culvert built under the new line, its banks, &c., &c., the masonry of which will be paid for at the prices tendered for the kind of work of which the side walls are built, *i.e.* whether coursed or rubble work, laid dry or in mortar. But in either case the covering must be large, flat, well-shaped stones, of a size to have a bearing of at least 8 inches on the wall on either side, and the foundation formed of timber and plank, with ranges of sheet piles at both ends, or at such other places and of such a length as may be directed.

CATCH-WATER DRAINS—must also be formed a short distance back from the top edge of the slope, to exclude from the cut the surface water of the adjoining lands; together with all other necessary ditches, &c., for the full drainage of the new line of railway and works connected with it.

All of the ditches, drains, excavation of foundation pits for masonry, &c., must be executed at the time, in the manner and the material disposed of, as directed by the officer in charge.

Fences are to be put on both sides of the land occupied by the railway; they are to have sound, straight, well-shaped cedar posts, 8 feet long, and 6 inches diameter at the small end, placed not more than 6 feet apart from centre to centre. They are to be let 3 feet 9 inches into holes bored in the ground for that purpose, and the earth around them must then be well packed, the posts properly lined, and suitable faces made to receive the boards. The latter to be in four continuous, uniform ranges of one inch pine boards, of approved quality, 10, 8, 6 and 4 inches in width, and in lengths of 12 or 18 feet. They are to be placed at such heights and distances apart as may be directed, put on so as to break joint properly, and be fastened with three-inch nails, two at every crossing of a post. A batten, one inch thick and 5 inches wide, must be fastened with nails 4 inches long over the boards opposite each post; after the posts have been cut to an uniform height, a cap piece, 4 x 6 inches pine scantling, must be well fastened with 4-inch nails on the top of them.

TUNNEL OR CULVERT.

The tunnel by which the railway is to be carried under the canal is to be of the best class of dressed masonry, laid throughout in hydraulic cement mortar, prepared as previously described for the locks. It will be about 650 feet in length, corresponding in range with the curve line of approach to it at both ends; it is to be 16 feet in width, and 18 feet high in the centre over the level of the rails.

The pit for it, if in clay, must throughout be excavated to the depth of $2\frac{1}{2}$ feet below the level of the rails, but the space to be occupied by the walls, for about 500 feet in the middle part of the culvert, is to be sunk 2 feet lower, or $4\frac{1}{2}$ feet below the rail level; and for 75 feet at each end, the foundation for the walls must be sunk 6 feet below the level of the rails.

From rear to rear of the seats for the walls the distance will be about 84 feet, on which an allowance for side slopes, of about $1\frac{1}{8}$ horizontal to 1 vertical, will be made.

The seat for the side walls must be taken off level and smooth at the respective heights above stated, or at such others as the nature of the foundation, in the opinion of the engineer, may require.

The excavation for the culvert pit will not be considered as commencing until after a cut 24 feet in width at bottom, with side slopes of $1\frac{1}{2}$ horizontal to 1 vertical has been completed to the depth and gradient previously stated; below and outside of these lines, within the space to be occupied by the structure, will be measured and estimated as "Culvert Pit Excavation."

In case rock be found at a higher elevation than required for the railway track through the tunnel, the pit from the surface of the rock downwards will only be made about 1 foot wider on each side than the space required for the side walls, and the bottom will not be sunk lower than about 3 feet below the level of the rails, if the rock is of a sufficiently sound and compact nature to warrant this course being adopted.

The side walls or abutments are to be 6¼ feet thick at the springing of the arch, increasing in thickness downward an average of about 1½ inches for every foot in height, *i.e.*, the walls are to be 8 feet wide at the bottom, and at the top of the first 2 feet an offset of 4 inches is to be made on both sides, the face is then to have a batter of 1 in 24, and the rear is to be carried up plumb; but at ⅓ and at ⅔ of the height of the walls, an offset of 4 inches each will be made.

In rear of the abutments counterforts 10 feet long, 6 feet wide at the bottom, and 4 feet at the top, are to be carried up from the foundation to within 2 feet of the crown of the arch; they are to be placed directly under the centre of the banks of the canal, and under that of the raceway, making in all 6 counterforts, at the places and of the dimensions stated.

Up to within 2 feet of the level of the rails, the walls are to be built of heavy block masonry, properly bedded and bonded throughout, and laid in full mortar beds. The lower or foundation course must be at least 10 inches in thickness, in blocks of not less than 9 feet area, laid in a full "swimming" bed of mortar, placed upon the seat prepared for the walls.

The stones to be used in all this part of the abutments must be picked to fair beds and made of a uniform thickness, so that the horizontal joints, when the stones are laid, shall not exceed five-eighths (⅝) of an inch; the sides and ends of the stones must also be scabbled in such a manner that the vertical joints shall not be more than 1 inch and a quarter (1¼).

The abutments over the heights above mentioned (2 feet under the top of the rails) are to be of a like class of work as described in a preceding part of this specification for the cut stone portion of the locks, *i.e.*, the face stones are to have 2 and 3 feet depth of bed in the alternate courses, with headers of 4½ feet depth of bed placed not more than 9 feet apart in every course. The face, beds and joints of all the stones to be dressed are laid to the horizontal and vertical joints therein stated.

The backing stones of the abutments must also be prepared, arranged and laid as provided for those in connection with that part of the lock walls above referred to, and every precaution adopted to make the whole of the best and most substantial class of masonry.

The arrangement of courses on both sides of the culvert must be such that the course under the springing line of the arch shall be at least 3½ feet width of bed—the face of which, instead of battering as those below it, is to be reversed and overhang at the rate of one in twelve, and be laid so that at the top it shall have a projection of three inches, to form in part a bearing for the centering.

The arch to be a semi-circle of about 8½ feet radius, and must be formed of regular and unbroken courses of stone of the full depth, laid in full mortar, to joints at no place exceeding one-fourth (¼) of an inch.

The voussoirs must be *two feet two inches* in depth of bed, and when prepared must have a mean thickness of at least 12 inches. Their beds must be dressed to radiate truly from the centre of the arch, and for the width of two feet from the line of soffit they must be kept full so as to present a fair, even surface throughout.

They must be in lengths of not less than 2½ feet, and the arrises at the ends must be good, and the joints kept full for at least two-thirds of the depth of the stone. The intrados, or lower side of the arch must be dressed, and the beds of the voussoirs, across the whole length of the arch are to be chamfered to the breadth and depth of one inch.

The heads of the ring stones are to project one inch and a half beyond the line of the spandrel or retaining wall, and at the joints are to be chamfered as stated for the beds of the voussoirs. In other respects the stones are to be dressed in like manner as described for the face of the abutment.

All the stones of the different courses must break joints over and with each other at least 12 inches, and throughout they must be laid in full mortar-beds, and driven by means of a heavy wooden maul, to the joints above stated, one-fourth of an inch.

All the end joints must be carefully and fully grouted as the works proceed, and every precaution adopted to render all the joints between the stones, and the arch as a whole, as well as the works connected with it, impervious to water.

The abutment walls are to be carried up to within 18 inches of the crown of the arch, and the whole well moistened with water, then thoroughly flushed on the back and levelled up, or rounded to a moderately smooth surface with cement mortar of such a depth and in such a manner as may be directed.

At both ends of the structure the wing walls are to be circular, each end terminating in a pier 4 feet square at top, and having one foot projection on the front side. They are to be $7\frac{1}{2}$ feet in thickness next the abutments, 5 feet at the outer end, and are to be carried up to a batter of one in twenty-four, to the height of $4\frac{1}{2}$ feet over the under side of the arch at the centre. The foundations are to be stepped off to suit the banks, but the highest part of them must in all cases be six feet below the line of the adjoining slope.

The face of the walls to be of stones 20 and 30 inches depth of bed in the alternate courses, with headers in every course $3\frac{1}{2}$ feet depth of bed, placed not more than 9 feet apart; all the stones to be dressed and laid so that the horizontal and vertical joints shall not exceed three-eighths ($\frac{3}{8}$) of an inch.

On each side of the ends of the structure at about $2\frac{1}{2}$ feet back from the side lines, a pilaster having about 12 inches projection, with a batter of one in twenty-four on both face and sides will be carried up to about $5\frac{3}{4}$ feet above the centre of the arch, where it will have a width of $3\frac{1}{2}$ feet.

The ends up to the springing line are to have a like batter, thence upward the head of the arch and wall over it will be vertical, and the side string course is to be returned into the pilasters.

The outer ends or portals of the tunnel and wings are to be of rock work, with a margin draft of one inch along the sides and ends of the stones, angles of pilasters, and elsewhere as may be required.

The coping for the walls must in all cases be at least 12 inches in thickness, that for the wings to be three feet wide on top; for the piers $4\frac{1}{4}$ x 4 feet, and over the arch and abutments $3\frac{1}{2}$ feet in width. They must all be dressed so that the horizontal and vertical joints shall not exceed one-fourth of an inch, and the upper sides and faces of all of them as well as the face of the course immediately below, must be neatly dressed throughout, and laid to such lines and projections as may be directed.

The arches are to be formed on properly framed centers of approved construction and must be supported on slack blocks such as will admit of their being gradually lowered.

Contractors are requested to bear in mind that the cost of centers and covering must be embraced in the price tendered for the masonry.

The spaces in rear of the abutments and around the countertorts must be properly cleared out, and afterwards filled with a good description of puddle, well cut, trodden and pounded. As soon as the adjoining banks will admit, the puddle beds or walls are to be carried up four feet in width, to within one foot of the crown of the arch, and the spaces between the puddle and the solid banks are to be made up with material hauled on in carts or wagons as provided for the formation of other banks necessary to be water-tight, and they are to be carried up in this manner to a like height as the puddle walls above mentioned. When the embankments thus formed have been fully consolidated, a puddle bed is to be made between the original bank on one side, across the tunnel to the solid bank on the opposite side, which must be carried up to canal bottom and extend the whole length of the tunnel.

In case the lower part of the cutting is rock, concrete will be used in rear of the walls up to the surface of the rock.

If considered necessary for the security of the structure, the contractor must lay a foundation of concrete for such a width, length, and depth as may be directed.

A channel along both sides of the tunnel will be formed of pitched stone of like dimensions, laid on a bed of well pounded sand in a similar way as provided for other portions of the water-courses, except that they will be narrower and deeper, and that the sides of the stones must be roughly scabbled to suit the position they are to occupy. If so directed, this part of the water-courses must be well grouted after the stones are placed.

The culvert for passing the water of the "Ten Mile Creek" is to be lengthened about 70 feet, and will be of a like class of masonry, laid in hydraulic cement mortar as that of the present structure, which is built upon a foundation of timber and plank, is 10 feet in width between the side walls and has a semi-circular arch, the soffit of which, in the centre, is 11 feet over the floor.

The foundation for the extension, if the nature of the bottom admits, will be formed in a similar manner, the wings made of a like form and extent, and the whole of the work carried out, executed and finished in a way equal, at least, to that of the existing culvert; the price tendered for masonry to include centers.

In case it should be found necessary, the contractor must provide and drive a sufficient number of bearing piles to carry the structure, or a foundation may be formed of concrete; but in either case the floor will consist of timber and plank; and two courses of three-inch sheet piles of such depth as may be required must be put in across the foundation—one at the upper end of the side walls, and another at the outer end of the wings.

The trenches cut for the sheet piles must be properly filled with a good description of puddle.

It is to be clearly and distinctly understood that all the works connected with the formation of the canal and its embankments, construction of locks and weirs, as well as all those connected with the new line for the diversion of the railway, embraced in this section (12), must all be conducted and carried on in such a manner as not to interfere in any way or shape with the working of the present line of the Great Western Railway, as the contractor will be held strictly and legally liable to the proprietors of the railway, the public or individuals, for any damage, loss, accident, or detention which may be sustained through his acts, whether the same arise from oversight, neglect, or from a desire to proceed with the works expeditiously, or from any other act or cause whatever.

The contractor must construct dams wherever it may be necessary to keep out water during freshets, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, bailing, removing ice and snow, and every contingency directly or indirectly connected with unwatering the lock, weir and culvert pits and all other portions of the works during their progress, and up to the full completion of the whole, and the satisfactory removal of all coffer dams and other temporary works, must be stated in the bulk sums stated in the tender for unwatering the works.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction, but detailed working drawings, arranged, modified and adapted to each lock and weir foundation, for the tunnel, and all such other parts of the structures as may be required, will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery, and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All the materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by a deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 1st day of May, 1877.

JOHN PAGE,
Chief Engineer of Public Works

OTTAWA, 22nd May, 1875.

APPENDIX No. 9.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTION No. FIFTEEN of the Enlargement.

This section is about 2,050 feet in length, and is situated to the eastwards of Thorold Village, chiefly in the ravine formed by the head waters of the "Ten Mile Creek," and extends southwards, from near Brown's Cement Kilns, to a point 200 feet south of the crossing of what is known as Hoover's Road.

It includes the formation of the canal for the whole distance above stated, the excavation of lock-pits, foundations for weirs, cuts for raceways, and a water-course for the "Ten Mile Creek;" also, all the excavation necessary to admit of the track of the Welland Railway being moved 120 feet to the westwards of its present line.

It also embraces the construction of two lift locks (gates excepted), two regulating weirs, bridge abutments, and such other structures as are hereinafter described, or the contractor may be called upon to execute.

The centre line of the canal, and the position of the several structures will correspond nearly with those represented on the general plan exhibited; but the Department of Public Works reserves to itself the right of changing the whole, or any part of the line, as much as one hundred feet either to the right or left of the line at present marked out on the ground, and of altering the position of all or any of the structures three hundred feet either to the north or south of that indicated on the plan. Such changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal is to be made from 100 feet to 160 feet in width, of the full depth of 13 feet throughout below the assumed water line. In earth or clay-cutting, the side slopes are, for the most part, to be made 1½ horizontal to 1 vertical; and in rock-cutting are to have an inclination of 3 inches to the foot rise. All angular and projecting points of

rock on the sides of the cut are to be broken off; and the side slopes, in both rock and earth excavation, must be dressed fair and uniform, corresponding to the lines marked out by the officer in charge.

If the rock, which forms the bottom of the reaches, be of an open and porous nature, or have numerous rents or fissures in it, such as would allow the water to escape, it may be found necessary to increase the depth from 18 to 24 inches, in order to put in a lining of clay; otherwise, if the openings between the ledges of rock be large, but not numerous, the bottom will be kept at its proper depth, and the openings well cleared out, and subsequently filled with concrete.

A towing path is to be formed on both sides of the canal at the height of 4 feet over the water line, and made 15 feet wide on top, with an inclination longitudinally not exceeding one in fifteen, or such other grade as may be directed.

On the west side of the canal, the bank formed for this purpose, as well as the embankments in rear of the lock walls (on both sides), and at the regulating weirs, &c., must be made up of the best material that can be obtained from the excavation on the east side of the ravine, or, if required, it must be taken from any place that may be pointed out in the vicinity; but wherever taken from, it must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time; and if the work be done at a dry season of the year, water must be thrown over the banks to assist in consolidating the material.

The seats of all embankments must be fully cleared of all turf, muck, loose stones or other objectionable materials, and be prepared in the manner required by the officer in charge, whose examination and approval must be had and obtained before any part of an embankment is commenced.

Puddle walls are to be carried up in such of the embankments as the engineer may consider necessary.

All the earth, clay and rock excavated on both sides of the ravine, or at other places on the work, except what is required for the embankments above mentioned; the making up of road approaches; building slope walls, or for other necessary purposes, is to be deposited in such a manner as may be directed in the valley of the "Ten Mile Creek," at and beyond the north end of the section, and on the west side of the present line of the Welland Railway.

The inside face of the banks and raceways on this section are to be supported by walls of a heavy and substantial class of rubble masonry, carried up from one foot below the bottom of the canal or bottom of the raceway, in clay excavation, and from the surface of the rock in rock-cutting.

Along the inner side of the western bank the walls, for the most part, will be of a like height as the towing path, be 2½ feet wide on top and have a batter of 2 inches or more to the foot on the front side, and on the rear side increase at the rate of 3 inches to the foot for the first four feet from the top, thence downwards they are to be plumb.

Retaining walls of like dimensions are to be built alongside of the raceway where formed by an embankment; and at other places on the east side of the reaches, &c., a heavy slope wall will be laid at such an angle as may be directed.

The whole of the retaining and slope walls must be built of sound, durable, flat and well-shaped stones, not less than 6 inches thick, and two feet or more in

length, with at least 3 feet area of bed, laid so as to form proper bond over and with each other in both front and rear; the faces of the stones must be hammered or scabbled to a line corresponding to the position they are to occupy in the work.

Headers, not more than 7 feet apart, and at least 3 feet depth of bed, are to be placed in each course; and the coping stones must be 2½ feet wide, and in pieces at least 9 inches thick, not less than 3 feet long.

In rear of each of these walls, a space of about 15 inches in width is to be made up with small stone or quarry waste, well rammed.

Any stone that may be taken out of the rock excavation, suitable for these walls, can be laid aside for that purpose by the contractor, who must otherwise provide for the whole or any quantity that may be required.

Along by the foot of the outside slope of the western bank of the canal, an open channel will be formed for passing the waters of the "Ten Mile Creek" to the lower part of the valley. It will, generally, be 12 feet in width and 6 feet in depth, made to a like inclination as the track of the Welland Railway. The sides and bottom of about one half of this channel are to be formed of rubble masonry, either laid dry or in cement mortar, as may be required.

As previously stated, the Welland Railway is to be moved 120 feet to the westwards; to accomplish this the western bank of the ravine must be removed to the full extent represented on the general plan, so that between the point where the change of line commences to where it terminates, the grade will be the same throughout as it is at the present.

The road bed of the new part of this line must be properly graded, and the rock part of it lowered to admit of a sufficient depth of ballast being put on. All such ditches and drains must be cut and formed, as may be necessary to carry off the surface water.

This work must be proceeded with at such a rate as will enable the necessary arrangements to be made for changing the line of the railway at the earliest possible period after the works are commenced; nevertheless, the operations must be conducted in such a manner as not to interfere in any way or shape with the traffic, as the contractor will be held strictly and legally liable to the proprietors of the railway, the public, or individuals, for any accident, damage, loss or detention which may be sustained through his acts, whether the same arises from oversight, neglect, or from a desire to proceed with the works rapidly, or from any other act or cause whatever.

Locks.—The locks are to be 270 feet in length between the gate quoins and 45 feet in width between the side walls at the level of the lower reach. They are to be constructed of dressed stone masonry, laid throughout in hydraulic cement mortar, and placed on foundations prepared as hereinafter described.

The pits excavated for them are to be made of suitable dimensions to admit the side and wing walls, and to correspond with such lines as will be marked out on the ground by the officer in charge.

In rock the sides of the cut are to be made perpendicular, and a space of one foot left in rear of the walls for concrete; and in clay-cutting such slopes are to be formed as may be required for stability.

The bottom must in all cases be trimmed smooth and level, at a proper height to give a fair and uniform bearing to the foundation timbers or base of the walls.

The material excavated from the lock pits, unless otherwise directed, must be spoiled at the north-west end of the section in like manner as that described to be taken from the reaches, adjoining banks and other portions of the works.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where a lock is to be built, the walls will be commenced upon it without an artificial foundation; but if the rock be unsound, the fissures in it numerous, the strata thin or irregular, a floor of pine timber, covered with 3-inch plank, will be laid at a height to form a bearing surface for the walls, and a similar course will be adopted where the foundation is of earth or clay.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

When on clay they are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock; and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the walls, all of which must be counterhewn, and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches diameter) passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through, and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &C.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must, in all cases, be made of the best materials for that purpose which can be obtained in that vicinity; cut, mixed, prepared and laid as directed by the officer in charge.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally, 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking in both courses must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inches diameter, two in each end of a plank, and on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan, to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches—checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 3 inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons, and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half ($1\frac{1}{2}''$) diameter, have upset heads, and be well ragged at the point.

Where the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge on both sides will be connected with a stop-water timber let into the rock.

STOP-WATERS.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platform, checks are to be cut in the rock 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, to each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, $1\frac{1}{4}$ inches diameter, placed not more than 10 feet apart.

Stop-waters, similar to those above described, are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than those occupied by the platforms, there are to be timbers, 12 inches square, laid 6 inches apart; also for a distance of 12 feet below the lower side of the platform and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, $1\frac{1}{4}$ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The locks on this section are each to be 14 feet lift, and the side walls carried up to two feet over the surface water level of the upper reach, with which they are connected, or to a height of 29 feet. The chamber walls are to be 10 feet wide at bottom, with counterforts in rear, 6 feet long in line of wall, and 3 feet projection, placed not more than 12 feet apart—the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping; and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound and durable stones; those which form the face work must be free from drys, seams, or other defects, and must be at least equal in every respect to the best class of stones used in the existing locks.

The face stones must be of an uniform texture and colour, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls between the points above mentioned are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed $\frac{3}{8}$ of an inch.

CUT STONE—to be neatly dressed and boucharded; made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall and not less than 2 and 3 feet depth of bed on the alternate courses. In each course must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers, in the alternate courses, must be at least 1½ times their height and the headers 2¼ times their height; and in all cases the tail of a header must have a width of ⅔ the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least 4½ feet face and 5½ feet depth of bed; the latter 5¼ feet face and 4½ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet, and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled, as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain-wells in the positions indicated on the plan; each well will be 2 feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall.

In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stones, when in place, shall not exceed $\frac{3}{4}$ of an inch.

BACKING—to consist generally of large well-shaped stones, not less than 6 inches in thickness, and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls; except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces will extend over the buttresses, for the chain-wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping, must, however, be at least $6\frac{1}{2}$ feet square on top and two feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed $\frac{1}{4}$ of an inch.

A dowel, 4 inches long, of $1\frac{1}{2}$-inch iron, to be inserted in every joint 15 inches back from the face, and 6 inches from the top.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be 7 feet wide at bottom, 3 feet on top, built of coursed rubble masonry, and covered with suitable coping.

When locks are wholly or in part in rock cutting, the space between the back of the walls and rock must be made up of concrete, well mixed and pounded, and carried up simultaneously with the walls.

CONCRETE—where used, must consist of an approved quality of stone, broken to cubes of $1\frac{1}{4}$ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand in such proportions as may be required.

MORTAR.—The whole masonry of the locks must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement; or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings, provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about $1\frac{1}{2}$ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor; and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at back of the walls, made up in the manner already described, are to be 25 feet in width, and have a declivity of 6 inches outwards from the lock.

RUBBLE WALLS—forming the extension of the wings at the head and foot of the locks must be formed of a large class of sound, well-shaped, durable stones, properly bonded over with each other, and laid in cement mortar for such a distance below the lock as may be directed.

These walls are to be built to such lines as will form a suitable connection between the locks and retaining walls, or the slope walls as the case may be; and the face of the stones are to be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

At the head of the upper lock on this section there will be a road crossing, to provide for which walls in continuation of those of the lock will be built to form bridge abutments as shown on plan.

They will rest on a foundation of timber and plank, and have sheet piles at the toe of the walls, and will be of a like class of masonry as described for the chamber walls of the locks, but with certain modifications, the details of which will be furnished by the engineer.

In line with the swing bridge, two abutments will be built to receive the superstructure of a fixed bridge over the raceway; and also two abutments for a fixed bridge over the Welland Railway.

The superstructures of these bridges, also the fixtures and machinery required for working the swing bridge, will, however, be made a separate contract; but all masonry required for them is to be done by the contractor for the locks.

REGULATING WEIRS—arranged as indicated on the general plan, or in such other positions as may be required, are to be constructed as hereinafter described.

The space excavated for the weir to be sufficiently large to admit the side walls, and be at least 5 feet below the surface level of the lower reach.

Foundation to be formed of pine timber, 12 inches square, laid 12 inches apart—the spaces to be filled with a good description of puddle, well beaten down; the floor to be of 3-inch pine plank, treenailed to the timbers, and a second course of plank 2 inches in thickness, is to be laid between the wings below the breast wall. There are to be three ranges of sheet piles across the foundation; one above, and another below the breast wall, and the third at the lower end of the wings.

The masonry of the wings to be of rock work, face stones to be 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course, dressed and laid so that the end joints shall not exceed ¾ of an inch.

BREAST WALL—to be of stone, 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, and not more than 9 feet apart, all of them dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame work of the sluices, and the lower side to be rock-faced work, laid to a batter of about 4 inches to the foot rise.

There are to be four sluice-ways through this wall, each 4 feet wide and 4 feet high, the sides of which are to be dressed smooth—sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

Breast wall coping to be dressed 4 feet wide on top, increasing in width downwards, the stones are to be well dowelled together. Wing coping to be 3½ feet wide, to have the beds and joints kept full throughout, and top neatly boucharded.

BACKING—to be of a like class of work as that described for the rear part of the lock walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared in the manner already stated.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction; but detailed working drawings, arranged, modified and adapted to each lock and weir foundation, and for all such other parts of the structures as may be required, will be furnished as the work proceeds.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of material found in the cuttings or borrowing pits, except absolutely connected "quarry rock" and boulders containing more than *one-third* of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and bank, forming and grading towing-path, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to this specification.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been completed and extended, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

MATERIALS, SERVICE GROUND, &c.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish, and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

The party whose tender may be accepted, shall be subject to all the clauses and conditions in regard to payments, retained percentage, and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada; and to such other special conditions as the nature of the works may, in the opinion of the Minister of Public Works, seem to demand.

It is to be clearly and distinctly understood that within *nine months* after the date at which a contract shall have been entered into, the whole of the works connected with the removing of the west bank of the ravine, to the extent required for changing the line of the Welland Railway, must be completed.

That the foundation of the locks shall be prepared, and at least 6 feet in height of the side wall masonry of each lock laid on or before the 20th day of September, 1874; and the whole of the lock masonry shall be finished by the 20th day of September, 1875; and the entire work embraced in the contract completed on or before the 1st day of December, 1876.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 16th December, 1872.

APPENDIX No. 10.

WELLAND CANAL.

SPECIFICATION of work to be done on SECTION No. SIXTEEN of the Enlargement.

This section extends from the south termination of No. 15 to within a short distance of where the canal intersects the line of the Welland Railway, in what is known as Marlatt's Pond, its total length being about 3,500 feet.

The work upon it will chiefly be clay and rock excavation; the construction of a syphon culvert of two arches, to pass the waters of the "Ten Mile Creek"; the building of such slope walls as may be required, etc., etc.

The canal will generally be made from 100 to 110 feet wide at bottom, and the depth of 13 feet below the assumed water line; but for a distance of about 800 feetat the upper end of the section, the bottom will be 170 feet in width.

The centre line is marked out on the ground and represented on the general plan, but the Department of Public Works reserves to itself the right of changing the whole or any part of the line as much as five hundred feet, either to the right or to the left of that indicated on the plan.

This change, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution of the prices tendered for the respective items of work.

In earth or clay excavation the side slopes are generally to be made *two* horizontal to *one* vertical, and in rock-cutting they are to be 3 inches to the foot rise.

All angular and projecting points of rock on the sides of the cut are to be broken off, and the side slopes in both rock and earth excavation must be dressed fair and uniform, corresponding to the lines marked out by the officer in charge.

A continuous towing path is to be formed on both sides of the canal, 15 feet wide on top and 4 feet over the water surface.

The seats of all embankments must be fully cleared of all turf, muck and loose stones, and other objectionable materials; and all roots must be cut and grubbed out,

and the whole prepared in the manner required by the officer in charge, whose examination and approval must be had and obtained before any part of an embankment is commenced.

When the ground where an embankment is to be formed is below water level, the surface must be removed for such a depth as may be directed for the entire space to be occupied by the bank.

At the north end of the section the inside face of the banks are to be supported by walls of a heavy and substantial class of rubble masonry, carried up from one foot below canal bottom in clay excavation, and from the surface of the rock in rock cutting.

These walls, for the most part, will be of a like height as the towing path, be 2½ feet wide on top, and have a batter of 2 inches or more to the foot rise on the front side, and on the rear side increase at the rate of 3 inches to the foot for the first 5 feet from the top, thence downwards they are to be plumb.

The whole of the walls must be built of sound, durable, flat and well-shaped stones, not less than 6 inches thick and 2 feet or more in length, with at least 3 feet area of bed, laid so as to form proper bond over and with each other in both front and rear.

The faces of the stones must be hammered or scabbled to lines corresponding to the position they are to occupy in the work.

Headers not more than 7 feet apart and at least 3 feet depth of bed are to be placed in each course, and the coping stones must be 2½ feet wide and in pieces at least 9 inches thick, not less than 3 feet long.

In rear of each of these walls, if so directed, a space of about 15 inches in width is to be made up with small stones or quarry waste, well rammed.

Any stone that may be taken out of the rock excavation, suitable for these walls, can be laid aside for that purpose by the contractor, who must otherwise, if necessary, provide for the whole or any quantity that may be required.

At the place indicated on the plan, a syphon culvert will be built to pass the waters of the "Ten Mile Creek," the foundation of which must be sunk to 10 feet under the bottom line of the canal, and the material deposited where directed.

This structure will be of masonry, built with two arched openings, each 6 feet in width. The foundation will be formed of pine timber 12 inches square, laid 6 inches apart, the spaces between which must be filled with puddle, well rammed, or concrete if directed.

Floor to be of 3-inch well-jointed pine plank, laid so as to break joints at least every three feet in width, and be secured with 7-inch pressed spikes, two in each end of a plank, and one on alternate sides at every crossing of a timber.

A course of 3-inch sheet piles, sunk 4 feet below the floor timbers, is to be placed at each end, for which trenches about 2½ feet in width are to be dug and afterwards well filled with the best description of puddle. The heads of the piles are to be secured to the foundation timbers by 7-inch pressed spikes, two in each plank.

The face stones of the side walls or abutments to be at least 2 feet width of bed, with headers not more than 8 feet apart; centre pier to be 2 feet in width, made up of

stones the full thickness, suitable springers to be prepared, and the beds of the arch stones, 18 inches in depth, are to radiate truly.

The faces of the abutments, centre pier and soffit of the arches are to be dressed; the joints and beds made so as not to exceed $\frac{3}{8}$ of an inch mortar joints; the breasts and sides of the wells are to be of a like class of masonry as the abutments; the wings and parapet walls to have dressed beds and joints and a "rock face."

Coping to be 3 feet wide and 12 inches thick, in lengths of at least 3 feet—top to be neatly boucharded; beds and ends to be dressed so as to lay to mortar joints of $\frac{1}{4}$ of an inch.

The abutment walls and spandrel filling to be carried up to within one foot of the crown of the arches.

A puddle bed 2 feet in depth, and for the entire width of the canal and embankments, is to be laid over the culvert.

Detailed plans of the structure will be furnished by the engineer.

From the lower end of this culvert along by the foot of the outside slope of the western bank of the canal, an open channel will be formed for passing the waters of the "Creek;" it will generally be 12 feet wide, and 6 feet deep, made to such an inclination as may be required.

The bottom to be formed of pitched stone, and the sides built of rubble masonry, either laid dry or in cement mortar, as may be directed.

It will be seen by the general plan that at a point near the lower end of the section, the Welland Railway is to be moved 120 feet to the westwards of the present line; to enable this to be done, the contractor must, when directed, form the necessary embankment of such a width, and with such slopes as may be required, and of a height suited to the present grade of the railway.

The embankments on both sides of the canal at the upper and lower ends of the section must be made up of the best material that can be obtained from the excavation, which must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time, and if the work be done at a dry season of the year, water must be thrown over the banks to assist in consolidating them.

PUDDLE BEDS—where required to be made in any of the banks, must be carried up at the same time that the banks are formed.

They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered properly, cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

All the earth, clay and rock excavated from the prism of the canal and adjoining banks—except what is required for the embankments above mentioned, the making up of road approaches, building of slope or retaining walls—will be deposited in the low ground at both ends of the section, chiefly on the east side of the canal.

The distance which part of the material may have to be hauled will be about 1,200 feet, the cost of which must be embraced in the price stated in the tender for excavation.

Spoil banks must be made of an uniform height and be at least 20 feet back from the front edge of the towing path, and have an inclination outwards from the canal of at least 1 in 20. Side slopes to be 2 to 1.

When the depth of cutting exceeds 17 feet, the banks must be removed to that height for the full width of the towing path and side ditches, as may be required.

There are to be only two classes or denominations of excavations recognized, namely: 'earth," and "rock;" the former to embrace all kinds of materials found in the cuttings or borrowing pits, except absolutely connected "quarry rock," and boulders containing more than one-third of a cubic yard.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, grading towing paths, and completing everything connected with the excavation and embankment on the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

Wherever a public road crosses the line of the canal, the contractor must keep open, at his own cost and expense, convenient passing places during the progress of the works, and he shall be held responsible for keeping the crossings in such condition that they can be used safely.

MATERIALS, SERVICE GROUND, &C.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work (embraced in the section allotted to him) as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

The party whose tender may be accepted shall be subject to all the clauses and conditions in regard to payments, retained percentage and otherwise, of the contracts generally entered into for the construction and execution of works under the Dominion of Canada; and to such other special conditions as the nature of the works may, in the opinion of the Minister of Public Works, seem to demand.

The works are to be commenced immediately after the party whose tender has been accepted shall have entered into contract, and the operations must be conducted in such a manner that the culvert under the canal shall be completed by the 1st day of April, 1874, and one-third of the entire excavation be finished by the 1st of July, 1874; two-thirds of the excavation done by the 1st of July, 1875, and the whole of the works completed on or before the first day of July, 1876.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 17th December, 1872.

APPENDIX No. 11.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTIONS Nos. SEVENTEEN and EIGHTEEN of the Enlargement.

The sections are situated on the new line between Thorold and Allanburg ; they are collectively 7,265 feet in length, and are to be let in one contract; they will therefore be dealt with in this Specification as forming only one section. The boundaries and general line of which are represented on the plan, and marked out on the ground.

It includes the formation of a new line of canal for the distance above stated ; the construction of a lift lock ; building the abutments and piers for two road bridges ; the piers and abutments for a bridge to carry the line of the Welland Railway ; the works connected with a set of guard gates ; two arched culverts ; a regulating weir and raceway ; towing path, bridges, and such other works as are herein described or the contractor may be called upon to execute.

The canal will generally be made 100 feet wide at bottom when sunk to the level of 3 feet below the top of the mitre sill of the present lock at Port Colborne ; side slopes in both excavation and embankment to be two horizontal to one vertical.

All permanent structures are to be placed sufficiently low for a depth of 15 feet water in the reach, or fourteen feet on the entrance lock sills at the assumed low water of Lake Erie, which is eleven feet on the sills of the present lock at Port Colborne.

The centre line of the channel and the sites of the different structures will, for the most part, be as represented on the general plan exhibited and marked out on the ground ; the Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line as much as two hundred feet, either to the right or left of that shown, and of altering the position of any one or all of the structures as much as three hundred feet either upward or downward from the place indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution of the price tendered for the respective items of work.

CLEARING, GRUBBING, MUCKING, &c.—From the spaces to be occupied by the banks of the canal and banks of raceway or wherever a water-tight bank is required to be made, all trees must be cut down; stumps, roots and bushes carefully and thoroughly grubbed, and the whole, together with logs and brush of every description, must be removed or burned as may be directed; but in either case without damage to adjoining property. Trees close to the line of the canal, which by falling might injure the banks or interrupt navigation, must be cut down and removed, if directed. All the clearing, grubbing, and removal of brush, logs, &c., &c., must be completed before the work of making up banks is commenced.

The material to be excavated on the section will chiefly be clay, some of which, in all probability, will be of a hard nature; part of it will be used to make up banks in the vicinity of where it is removed, but a larger quantity of the material must be disposed of as follows:

To make up the embankments through the valley in which Beaver Dams Creek runs will require fully one-half of the excavation on the section, one-third of this quantity is to be taken from the southern end of the section and will require to be hauled from 1,000 to 1,500 feet; the other two-thirds will have to be taken from the middle and northern part of the section and foundations of structures, and hauled from 1,500 to 3,000 feet.

Part of the material excavated from the lock-pit and the northern approach to it, must be used to form the banks through Marlatt's Pond after the seats for them have been satisfactorily prepared, as subsequently described.

If the material in the bottom of the cut through Marlatt's Pond is found suitable for making up the banks, it will be used for that purpose, otherwise it must be spoiled in the manner subsequently described.

In all cases where a bank adjoining the canal has to be made over sloping ground, whether the inclination be parallel to the canal or at right angles to it, or at any other angle, the seat must invariably be either cut down so as to give a level bearing, or be made into benches, each of which must of itself present a horizontal surface of sufficient width to admit of a suitable connection being made, and so as to guard against any tendency to slide.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a width in the centre of that space, or for the entire width to be occupied by the bank if required, and for such a depth as may be directed; the sods, muck, rubbish, brush, roots or loose earth thus removed must be hauled and placed at such a distance from the banks as the circumstances may require.

For preparing the seats of banks, the material removed will be measured in the "solid," and the quantity paid for at the same rate as for excavation on the section, which rate should be clearly understood to include the cost of handling all kinds of material necessary to effect the object, and the removal of the same to such places within the limits of the section or elsewhere as may be directed.

The line at the northern end of this section passes through what is known as Marlatt's Pond, where water-tight banks on both sides must be made, the water level on the new line being fully four feet higher than that of the present canal. The seats of the banks must therefore be thoroughly cleaned for their entire width and length by the removal of all sunken timber, logs, limbs, roots of trees and brush of every kind; also all silt, deposit and material unsuited for the base of a water-tight bank must be removed.

This may be done by machinery before the close of navigation this year, or it may be done when the water is drawn down next December, for the purpose of proceeding with works on other parts of the line.

In either case, all the logs, roots, stumps, &c., must be hauled and placed outside of the present water line, and so as not in any way to interfere with the water-course leading to or from the culvert intended to connect the pond on both sides of the new canal.

They must further be placed in such a position that they cannot drift or be drawn into the channel of the present canal, or into any place likely to obstruct the entrance to or from that part of the pond lying to the westward of the west bank of the new line.

At the level of the bottom line the seat for each of the side embankments must be prepared as above described, for a width of 91 feet, but where the bottom of the pond is below that level the width of the seat must be increased, and wherever a good foundation can be obtained above that level the width of the seat will be diminished. In all cases the increased or reduced base must be made of the width to correspond, at the respective places, with the lines of the side slopes.

It is probable that a depth varying from 1½ to 3½ feet below the present bottom line of the pond, and for the respective widths above stated, will have to be removed; this work will, however, form a distinct item which will be paid for by the cubic yard at the rate stated in the tender for that special purpose.

If the work is done before the close of navigation this year the quantity will be computed from levels and soundings made with reference to fixed and permanent bench marks. If it is done during the time that the water is drawn out of the reach of the present canal, between Thorold and Allanburg, the quantities will be measured as the work proceeds.

Contractors should, however, bear in mind that the only way of getting a dredging machine to the place is by opening a cut through the public road which passes across the pond. To admit of doing this the contractor would have to arrange with the Municipality or the Road Company, and besides be held strictly liable for any interruption to the traffic on the highway, as well as for any damages that might result from interfering with the road.

If this portion of the work is done when the water is out of the canal, there will, in all probability, be a considerable depth of frost to contend with where there is cutting; and at places where the bottom of the pond is lower than the line of drainage, there will be frost, ice and water to be dealt with.

Nevertheless, the seats of the banks must not only be prepared as stated, but the banks themselves must be made up to at least 2 feet over the surface water line of the present canal by the early part of April, 1878, except immediately at the place where an opening through each of them is to be left, to pass the snow floods and other drainage from the east, until the syphon culvert is completed.

In forming the channel across the pond, any material found suitable for banks is to be used for that purpose, and the balance spoiled where it will not interfere with either the new works or the water-course leading to and from the culvert.

The principal part of the material for making up the banks will have to be hauled from the lock pit and cuts adjoining it; this will render necessary a haul of from 400 to 1,900 feet, and the construction of a temporary bridge across each of the openings left for the flood water during freshets.

TOWING PATHS—to be formed on both sides of the canal, both in cutting and embankment. In each case they are to be made 15 feet in width on top, have an inclination outward of about twelve inches to a ditch formed at all places where the bank in rear of it is of a greater height. The ditch to be two feet or more in width at bottom, and have such an inclination as will carry the surface water freely to the culverts which pass under the canal, or to such off-take drains as circumstances may require to be formed.

In connection with them, where necessary, wells are to be sunk, from which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal, two feet or more below the assumed level of Lake Erie. These wells are to be from two or three feet square, and the culverts from them 15 to 24 inches square; they are to be built of rubble masonry, laid in cement; the bottom of both wells and culverts are to be of flat stones of a size to reach across the respective openings, and pass at least 6 inches under the walls on both sides, the covering of the culverts to be of flat stones of a length which will bear at least 6 inches on the side walls.

BACK DITCHES.—To carry off the surface water and such other natural drainage as it may be necessary to provide for, ditches are to be formed on both sides of the canal, at the places and of the dimensions required; care being taken that any present means of drainage shall not be interfered with before another outlet is provided. For any damages that may arise from this cause, whether the result of inattention or otherwise, on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

Wherever it may be found necessary to spoil materials removed from the cuttings, whether it be from its unsuitableness or distance from where it can be advantageously used, the bank must be kept back at least 20 feet from the edge of the cut, and if placed on ground higher than the towing-path, the material must be kept at least 10 feet back from the top edge of the slope.

The tops of spoil banks must invariably be made of such a height and width as may be directed, and their upper surface have a slight inclination outward from the canal.

BANKS, &C.—All the suitable material excavated from the prism of the canal, raceway, foundation pits, &c., must be hauled and placed, so as to make up the banks of the canal through low ground in rear of structures or wheresoever required within the distances or limits before mentioned. In all cases the best material must be placed on the side next the canal, and the coarse, inferior or less suitable kind must either be used to form the outer parts, or removed entirely beyond the line of the banks and spoiled where directed.

When making up the banks of the canal, or embankments at and in rear of structures and at all places where a bank is to be formed through or alongside of ground that is lower than the canal surface, or *wheresoever a water-tight bank is required, the material must be hauled on the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS—when necessary to be made for the security of any of the banks, must be carried up at the same time as the banks are formed. They must invariably be made of the best description of material for that purpose that can be obtained at any place on the section, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well

trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely "earth" and "rock." The former to embrace all kinds of material found in cutting the canal to its full width and depth within the northern and southern boundaries of the section, excavating lock and weir pits, bridge seats, &c., except absolutely connected "quarry rock," and detached stone or boulders containing one-third of a cubic yard and upward.

The prices tendered for these items must cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments through "Beaver Dams" Valley, through Marlatt's Pond at north end of section and in rear of structures; grading towing-paths, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner agreeably to the foregoing specifications. But as the price per cubic yard for each division of the work will be an average of the whole of that class, payments will only be made according to the comparative value of the work with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been executed and completed, the aggregate amount shall be the same as when the respective total quantities are calculated and extended at the prices stated in the contract.

LIFT-LOCK.

At a point immediately south of where the new line of canal crosses Marlatt's Pond a lift-lock is to be placed, which will form the northern terminus of the summit level, or that of a continuous stretch from Port Colborne downward, generally at the same height as Lake Erie; but with locks and other structures adapted to a higher level if at any time required.

This lock is the twenty fifth of the series from Port Dalhousie, and like the others it is to be 270 feet in length between the gate quoins, 45 feet in width between the side walls at about the surface level of the lower reach; the bottom is to be placed so that there shall be a depth of 14 feet water on the top of the mitre sill below the surface water line of the adjoining lower reach; the walls are to be fully two feet higher than what is called the Grand River level; they will therefore be about 27½ feet in height.

The lower wings of the lock are to be extended to form abutments for a bridge to serve as a road crossing. All the face work to be of dressed stone and masonry throughout, laid in hydraulic cement mortar and the whole placed on foundation as herein described.

The pit and foundation to be made of the full dimensions to admit of a foundation of the full area to be laid; the side, recess and wing walls built of the dimensions subsequently described and, as a whole, made to correspond with the lines and levels given when the works are in progress.

The bottom must at all places be trimmed smooth and fair at the level required to give an even, uniform bearing for the foundation timbers or base of the walls.

The material excavated from the pit, when of a suitable kind, must be hauled to some point within the respective distances above stated, and placed so as to make up the banks of the canal in like manner as described for other parts of the excavation on the section.

FOUNDATION TIMBERS—to be of pine timber, 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock, and must rest uniformly throughout their entire length on the bottom, and on sub sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counter-hewn, if so directed.

SUB SILLS.—Two ranges of sub sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square and of a length to reach from rear to rear of the walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches in diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through and secured to anchor-timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, &C.—Five trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best material for that purpose which can be obtained in that vicinity; it must be cut, mixed, prepared and laid as directed by the officer in charge.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform or sill timber under it with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid, must be driven up with wedges to water-tight joints; every three feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inches diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid; the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches, checked three inches into the platform timbers and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, three inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated with boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts, arranged as shown on plan, and the holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half ($1\frac{1}{2}$) diameter, have upset heads, and be well ragged at the points.

In case solid and suitable rock in thick layers is found at the proper level, at the place where the lock is to be built, the walls will be commenced upon it without an artificial foundation, and the mitre sill platforms will be made as above described; laid in a full bed of mortar, and be secured to the rock with fox and key-bolts, and at the outer edge on both sides will be connected with a stop-water timber let into the rock.

If the rock, however, be unsound, the fissures in it numerous, the strata thin or irregular, a floor of pine timber covered with 3-inch planks will be laid at a height to form a bearing surface for the walls, and generally a slightly modified course adopted to that above described for a clay foundation.

STOP-WATERS.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform.

Before a stop-water is placed in its berth, a piece of duck or canvas well saturated with white lead must be laid for the full length and width of the check; the upper timber

must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, $1\frac{1}{4}$ inches diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than those occupied by the platforms, there are to be timbers, 12 inches square, laid 6 inches apart, also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, $1\frac{1}{4}$ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

Where it is necessary to lay timber in the chamber of a lock, on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The lock will be adapted to the Grand River level as well as that of Lake Erie, and also to the reach below the summit level; the walls will therefore be about $27\frac{1}{2}$ feet in height. The chamber walls are to be $9\frac{1}{2}$ feet in width at bottom, with counterforts in rear, 6 feet long in line of wall, and 3 feet projection, placed not more than 12 feet apart; the recesses are to be 2 feet 8 inches deep at top and the walls of them $10\frac{1}{2}$ feet wide at bottom.

The face of the chamber and wings are, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, and the counterforts will terminate within five feet of the top of the coping.

All the masonry of the lock and other permanent structures herein described must be built of approved, sound and durable stones; those which form the face work must be of gray limestone, free from drys, seams, sand holes or other defects, and must be of uniform texture and color and laid in regular courses; the ashlar work may vary from 21 to 30 inches in height; the thickest courses invariably to be placed at the bottom and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of the lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls, between the points above mentioned are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed $\frac{3}{8}$ of an inch.

CUT STONE—to be neatly dressed and boucharded, made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall and not less than two and three feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face, and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least one and a half times their height, and the headers two and a quarter times their height; and in all cases the tail of a header must have a width of two-thirds the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least 4½ feet face and 5½ feet depth of bed; the latter 5½ feet face and 4½ feet bed in the top courses, increasing in dimensions downwards at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downward at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the recess wall. Patterns for the hollow quoins will be furnished by the resident officer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet, and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled, as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain wells in the positions indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock-walls are to be made at the angles and widths to permit the play of the chains, and of such height as the officer in charge may direct.

The sills and lintels to be of stone sufficiently large to reach across the opening, and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain, when slack, lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face of the recess walls, and are to be properly bonded over with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed $\frac{3}{8}$ of an inch.

BACKING—to be of an approved class of large, well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face-work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin, wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber, recesses and wing walls are to be 4 feet wide on top, increasing in width downward to the frost batter in the rear, and to the face batter of the walls; except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangement of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least $6\frac{1}{2}$ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches; the whole to be laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

A dowel 4 inches long, of $1\frac{1}{2}$-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

As previously stated, the lower wings of this lock are to be extended to admit of the construction of a bridge to carry the traffic of the main road between Thorold and Allanburg.

For this purpose, arrangements are to be made by which the roadway of the bridge is to be nearly on the same level as the coping of the lock and wings. The bridge will be placed so that when in position the centre of the roadway will be about 53 feet below the lower gate quoins of the lock. On the east side the wing wall, or that part of it

occupied by the bridge, is to be kept 3¼ feet lower than the coping of the lock, access to which, on the channel side, is to be by means of five or more steps cut out of the solid, leaving an inclined space 18 inches in width next the face of the wall.

The foundation for that part of the seat for the turntable east of the side wall is to be laid at 9 feet below the top of the lock coping, and must be formed either of timber and plank or of a stratum of concrete, as may be directed. It is to be 16 feet square, and placed so that its centre shall be 15 feet 9 inches back from the face of the side wall.

The wall to form the seat for the heel of the bridge must be commenced at least six feet below the surface of the adjoining ground. Small piers are also to be built in positions that will form a rest for the bridge when open.

The coping stone for the turntable to be of large size and not less than 15 inches in depth, the pivot-stone to be not less than 6 feet square and 2 feet depth of bed.

In the face of the west wing wall of the lock a recess is to be formed of the depth required, curved and otherwise adapted to serve as a seat for the bridge when in position.

These different arrangements for the bridge are to be of a like class of work as subsequently described for the upper works of the other bridges on the section.

The extension of the lower wings of the lock will be of a like class of work as that described for the chamber walls, which, together with all the masonry connected with the bridge seat and rests for the bridge at this place, will all be measured, estimated and paid for at the same rate as tendered for lock masonry.

BREAST WALL—to consist of one course of stone 18 inches in thickness and 3½ feet in width, laid in between the side walls 8 feet or more above the upper recess; the stones are to be properly picked, scabbled or dressed, laid to close joints, and secured to each other with dowels.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the lock must be laid in mortar, made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them, and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls, or any portion of them, are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course must be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds, where required at other places, are to be made in a similar way and of such dimensions as may be directed.

GUARD GATES.—At a distance of 800 feet south from the head of the lift lock (No. 25) arrangements are to be made for placing and working a pair of gates, heading toward the south, for the purpose of controlling the summit level in case of accident to the gates of the lock below.

The mitre sill for these gates is to be four (4) feet below the top of the mitre sills of the present lock at Port Colborne, which will make the walls a height of 25¾ feet.

The side walls are to be placed 45 feet apart at the surface water line of the lower reach and will be 92 feet in length, in each of which is to be a recess for gates similar to those in the lift lock; the wings at both ends will be alike, but at the northern end there will a straight line of about 15 feet before the curve of the wings commences; and in the face of the wall at the south end, for the entire height, two checks are to be made for stop-water timbers, when required.

These checks are to be six feet south of the recess, made 12 inches wide and two feet apart; at the top they are to be 6 inches deep, the depth increasing according to the batter of the wall, the rear part being carried up plumb.

The face work is to be of dressed stone which, together with all other parts of the walls, are to be laid in hydraulic cement mortar placed on a foundation of timber and plank as previously described for the lift lock.

The pit for this guard lock is to be made 98 feet long, 74 feet wide and sunk 6½ feet below the top of the mitre sills of the present lock at Port Colborne. The bottom must be trimmed off fair and level to receive the foundation timbers; sub sills, where directed,

laid; the timbers placed and the spaces between them filled with puddle or concrete, as may be required; mitre sill platform timbers must be dressed and drawn together by means of horizontal tie-rods and secured by vertical bolts; sheet piles to be of the length, prepared, put in and fastened; mitre sills to be of the dimensions, framed, put together and secured, and the whole of the materials for these different parts of the work must be of the best class of their respective kinds, and the workmanship connected with them be in every respect executed in the best manner, and invariably as described for similar works in the specification for the lift lock, whether the foundation be on clay or in rock.

The cut-stone for the face-work, the hollow and recess quoins and coping must all be of the respective dimensions, and throughout must be dressed in like manner as described for those in the lift lock.

The backing stones must also be of large size and the masonry throughout be laid as described for the lift lock, the specification for which, it is to be distinctly understood, shall apply, in the fullest extent, to the work to be done of all kinds, whether in the foundations or side walls to be built for the reception of the guard gates, class of materials, the order of building, and in all other respects.

To form a base for the side walls to be built at both ends of both the lift lock and the guard lock, a crib of framed timber work is to be put in at each place, of a height that the top timbers shall be one foot under the assumed low-water line of Lake Erie, at all places above the lift lock and below it, one foot under the surface of the reach.

They are to be from 32 to 40 feet in length, placed oblique to the centre line of the canal, made to a batter of one in twenty-four, adjoining the wing walls, where they are to be 14 feet wide at bottom; at the outer end they are to be 20 feet wide at bottom, and be carried up with offsets of 6 inches on the face for every 12 inches rise, so as to correspond in some measure with the batter of the wall, which is to increase gradually until within a distance, in each case, of about 90 feet from the end of the wing wall it has a like slope as that of the bank.

The sides and ends of the cribs are to be of pine timber, 12 x 12 inches, dovetailed at the corners, and connected by means of cross-ties 10 x 12 inches, dovetailed into the side pieces under and over them and arranged so as not to be more than 10 feet apart from centre to centre.

In the first course of side timbers the cross-ties are to be placed not more than three feet apart, to obviate the necessity of using floor timbers.

The ends of the face timbers adjoining the wing walls are to be let 5 inches or more into the masonry, from the floor of the lock upward for the entire height of the respective cribs. The ends of these timbers are to be secured to the masonry by fox and key-bolts or otherwise as may be required; the angles of the cribs and the cross-ties are also to be fastened with rag-bolts of the size and in the manner directed.

RUBBLE WALLS,—forming the extension of the wings at both ends of both the lift lock and the guard lock, must be built of a large class of sound, well-shaped, durable stones, properly bonded over and with each other, and laid in cement mortar for such a distance adjoining the wing walls as the circumstances may require. They are in all cases to be built to such lines as will form a suitable connection between the respective wing or side walls and the inner faces of the banks or adjoining walls. The faces of the stones must invariably be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

This section, as previously stated, embraces the construction of piers and abutments for two separate swing bridges, one to carry the line of the Welland Railway over the canal where it passes through Marlatt's Pond, and the other to carry the traffic of the road immediately north of Beaver Dam Creek. They are to be of masonry laid in hydraulic cement mortar, built chiefly in the form and dimensions herein stated and in the manner subsequently described, or that may be required.

The water-way at both places is to be in four divisions, the two centre ones of which in each case are to be 46 feet wide, and form the navigable channels.

In the vicinity of where the piers and abutments for the common road bridge are situated, a space 220 feet in length and 170 feet in width, is to be sunk to the depth of five feet below the top of the present mitre sill of Port Colborne Lock, and the sides are to be made to a slope of about one horizontal to one vertical. The material excavated from this space, as well from the seats of the piers, which are to be one foot and a half (1½) lower, or 6½ feet below the level of the mitre sills of the lock at Port Colborne, must be hauled and deposited to make up the banks of the new line through the Beaver Dams Valley. Contractors when tendering should bear in mind that it is only the widening beyond the side slopes and the deepening below ordinary bottom line of the prism of the canal which will be measured, estimated and paid for as bridge pit excavation.

The seats for the piers and abutments of the Welland Railway Bridge are to be excavated down to the surface of the rock if it is within five feet of the bottom line of the reach. All the material to be removed for this purpose will be measured, estimated and paid for as bridge pit excavation.

For the ordinary road bridge the centre pier is to be 16 feet square, the rest piers 16 feet in width and 9 feet thick at top; the centre pier for the railway bridge is to be 18 feet square, and the rest piers 18 feet in width and 9 feet thick at top. Through the centre of each of them an arched culvert 8 feet in height and from 6 to 8 feet in width is to be made on a line ranging with that of the canal.

Unless rock is found within a few feet of canal bottom, they are to be built on a foundation of timber and plank, the top of which must be at least six inches under the bottom line; in every case these walls are to have a batter of one in twenty-four.

The arch stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom part of the arch or water-way, is to be of dressed and properly-jointed stones, of a size that two of them will make up the width of the opening, and the end of each pass 15 inches under the wall; the second course to project one foot into the opening on each side, and the third to project inward 6 inches.

The face stones of the piers to be two and three feet depth of bed in alternate courses, with headers in every course 4½ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stones are to be kept full, and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case must invariably be made up with flat-bedded stones, not less than 4 feet area of bed, and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that, when laid, the horizontal joints shall not exceed five-eighths (⅝) of an inch, and the vertical joints be not more than one inch and a quarter.

The seat piers to carry the ends of the common road bridge when in position are to be 9 feet thick at top, those for the railway bridge are to be 10 feet thick at top, all of which are to be parallel to the canal. The ends of those for the road bridge are to be at right angles to the face of the pier; the ends of those connected with the railway are to be made to an angle corresponding to the oblique line of the bridge; the sharp points at the upper and lower ends of the latter must be taken off at right angles to the sides or ends to such an extent as may at the time be considered necessary. They are all to be of a like class of material and workmanship, faced on both sides and ends, made to a batter of one in twenty-four, and the foundation for them must be formed at a like depth as described for the centre and rest piers.

At four feet from the top of these piers, or at such other height as may be required, offsets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, the foundations of which are to be laid at canal bottom, or at such other level above or below that point as circumstances may require. They are to be 7½ feet or more in thickness, carried up to a batter of one in twelve on the face to the water line, and made plumb in the rear to within four feet of the top, thence the wall will diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized, well-shaped stones, laid level in full mortar beds, and properly bonded throughout the wall.

The centre pier, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge, and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout, and dressed so as to lay to joints not exceeding one-fourth of an inch; and the top side must have a fair surface, be neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square, and two feet depth of bed; the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones for a width of four feet is to be twenty-four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

The coping on the piers for the seat, and the abutments of the road bridge, will be 10 inches in thickness at the centre of the road, curved on top, so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the *road bridge*, parapet piers are to be built 4½ feet square at base, diminishing upward—one of which at each end of the bridge must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers and finished with coping, as indicated on the plans.

The walls above and below the abutments, for a distance of 40 feet or more, are to be of masonry, arranged to wind gradually round to meet the line of the slope on the respective sides.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments they are to be laid either longitudinally or transversely, as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete, as may be directed.

The covering plank to be of pine, three inches thick, and must be fastened to the timbers with $1\frac{1}{4}$-inch white oak treenails eight inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

CRIB-WORK.—Between the centre and rest piers, as well as above and below them, and if the bottom is rock, above and below the piers for the seat of the bridge, crib-work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, for the road bridge 16 feet wide at top, and for the railway bridge 18 feet wide at top, in both cases, increasing downward on both sides at the rate of one in twenty-four; and through the middle of them, longitudinally, a clear water-way must be formed of such dimensions as may be directed.

Transverse openings are also to be made in the crib-work adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the arch-ways formed through the masonry.

In the crib-work above and below the piers for the seat of the bridge, there are, in each case, to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of the cribs, the bottom to be of 3-inch plank, well-fastened with pressed spikes, and the top to be formed of pieces not less than 10 inches thick, and of a length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber, 12 inches square, straight, sound, full on the edges, and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$-inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 × 12 inches at both ends, and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be midway between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides so as to stand eight inches at the neck and 11 inches at the outer end.

Under the head of each tie, in the joint between the courses immediately below it, a block $1\frac{1}{2} \times 12 \times 12$ inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it, and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them, and be secured by bolts of similar dimensions in like manner as described for the transverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails two inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside, and extending from the lowest side timber up to the water-line. There are to be three ranges on a side, that is to say :—one at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be four inches thick and 10 inches in width, fastened from the inside with 10-inch spike, five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces, and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from eight to ten feet or more ; but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than three feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the sides next the channel.

The whole interior of the crib-work, except the water-ways, to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide-piers there are to be two ranges of wale timbers of white oak 6×12 inches ; the upper range to be fastened by means of screw-bolts, half an inch diameter, having upset heads let into wrought iron washers counter-sunk for them. The other range to be seven feet lower, and fastened by rag-bolts, $\frac{3}{4}$ of an inch diameter, having similar heads and washers to those in the upper range.

The wale-pieces to be put on in lengths of from 24 to 40 feet ; their upper edges are to be chamfered, and where they connect their ends are to be scarfed, covered with boiler-plate, and secured as directed.

For the protection of the structure and piers, three clusters of piles are to be driven within range of the centre pier, at suitable distances above and below it ; they are to be connected by means of thorough-bolts, straps, &c., and stand one foot or more over the cribs, &c., as may be required. Piles are also to be driven for the protection of the crib-work placed above and below the seat piers of the bridge.

In case the bottom is rock, the structure and piers are to be protected by means of three clusters of detached oak timbers placed vertically within range of the centre pier, at suitable distances above and below it ; their ends are to be let into the rock underneath for such a depth as circumstances may require. On the lower end of each timber a band of wrought iron $3\frac{1}{2}'' \times 1\frac{1}{2}''$ is to be fitted, and a bar of iron 2 inches diameter is to pass up vertically 12 inches into the timber, and 18 inches into the rock ; they are further to be

fastened by means of knees, straps and bolts, in the most secure manner that their position, &c., will admit of adopting. At top they are to be connected by means of thorough bolts, straps and otherwise, and stand one foot or more over the cribs, as may be required.

If the bottom is rock, vertical timbers will have to be put in and secured in a similar way as above described, instead of piles, for forming and supporting fenders on both sides above and below the bridge.

In case, however, that the bottom is clay, the bridge works will be protected in the following manner .—

FENDERS—are to be constructed on the land sides of both the water-ways, extending for some distance above and below the bridge, as represented on the general plan. They are to be formed by means of piles, caps, anchor timbers, and wale pieces, all of white oak timber. The piles to be not less than 11 inches diameter at the small end, driven from six to ten feet into the bottom, three in a group at about 12 feet from centre to centre, and one at the middle of each anchor timber when they exceed 25 feet in length. The caps are to be formed of two pieces, each 6 x 10 inches, arranged about eight inches apart, and checked obliquely to receive a dovetail formed on the head of the piles, to each of which they will be secured with wrought iron screw-bolts $\frac{7}{8}$ of an inch diameter, having upset heads and cast iron bevel washers let flush into the outside cap-pieces.

Immediately under the caps the anchor timbers will connect, with a dovetail, the outer piles, and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter ; they will bear on the inside pile of the group and the ends extend to the outside of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same or inside piles with a screw-bolt of one and one-eighth ($1\frac{1}{8}$) inch round iron, having upset heads and washers, sunk flush as described for the cap-pieces. Where the wale-pieces are scarfed they must be secured to the outer piles with screw-bolts $\frac{7}{8}$ of an inch diameter, with nuts, heads, &c., as described for the others. At seven (7) feet below the top of the cap-pieces, another range of waling 8 x 10 inches is to be put on and fastened throughout with bolts in like manner as for the upper tier.

The outer ends of the anchor timbers must be let into the banks for such a distance as may be required, and be secured to mud sills or cross timbers.

The superstructure of the bridges—both for the fixed and moveable parts—as well as the machinery for working them, will be made a separate contract.

Parties "tendering" should bear in mind that dams will have to be formed through Marlatt's Pond, on both sides of the site for the Welland Railway Bridge, and that seats for them must be prepared and the dams made between the close of navigation of the present year (1877) and the opening of the canal in the spring of 1878, or during the winter in which the water of the canal is drawn down for these and other purposes.

The bulk sum tendered for unwatering the space between these dams must include the removal of all surface water, leaks, springs or water that may in any way get into it during the time of excavating the foundation, and for the whole time required for the works connected with building the piers and abutments for the bridge. It should also include the clearing out and forming a site for the dams ; but the material in the dams themselves will be estimated, measured and paid for at the same rates as for excavation on the section.

In order to admit of building the piers and abutments for the Welland Railway bridge during the summer of 1877, a temporary turn-out to carry the traffic of the line past the place will have to be constructed. This it is proposed to place on the south side of the present track, and to form by short stretches of embankment at each end and pile trestle work through the water-covered space called Marlatt's Pond. It will be in the aggregate about 1,400 feet in length, about three-fifths of which will be on dry ground and two-fifths through water.

The trestles are to be formed in benches of four or more well driven piles in each measuring 16 feet from centre to centre of the outside range, and 6 feet from centre to centre of the two in the middle; they are to be placed about 20 feet apart on the line of the track. On the top of the two middle rows of piles, longitudinal cap-pieces 12 x 14 inches are to be formed, and transverse cap-pieces 14 x 14 inches are to be formed at each bench on the top of the outer piles and notched over and into the longitudinal cap-pieces. Four stringers each 12 x 12 inches are to be placed on top of the transverse caps, the two middle ones of which are to be immediately over the longitudinal caps to which they are to be secured at every five feet with bolts, one inch and a half diameter. Cross ties 8" x 8" are to be placed over the whole of the stringers about 12 inches apart; they are to be checked into the middle stringers, and their outer ends are to be checked or framed in between the outer stringers and top guard timber, and the whole fastened together at every third cross tie with screw-bolts, one inch and a half diameter. The two middle longitudinal stringers are to be further secured by means of screw-bolts, one inch diameter, connected with collar pieces fastened to the tops of the piles.

Two diagonal struts or ties 14" x 4" are to be fastened to the tops of the outside range of piles and as low down on the opposite outside pile as can be done when the water is drawn off—spikes to be $\frac{3}{4}$ inch diameter and 12 inches long; where these diagonals cross each other they are to have distance blocks between them and be fastened with a $\frac{3}{4}$-inch screw-bolt.

The piles will vary from 26 to 32 feet in length and must be of approved timber not less than 13 inches diameter at the small end; all of them must be well and satisfactorily driven.

Longitudinal timbers will generally be about 42 feet long, and must be scarfed at the ends and bolted as directed.

Cap-pieces to be 20 feet long, cross ties 15 feet long, diagonals 27 feet long.

Adjoining the embankments, on both sides, the piles are to be driven 10 feet apart longitudinally, and the whole well secured with diagonal braces.

Contractors, when tendering for forming this temporary deviation of the line of the Welland Railway are requested to bear in mind that the whole of the piles must be driven before the middle of November next, in order to admit of putting on the diagonal braces, and otherwise completing the whole of the work connected with the change of the line when the water is drawn off the canal for the purpose of executing this and other works.

The prices tendered for the respective items of work must include the removal of all the timber work in the "turn out" when no longer required, and piling it, as may be directed, on canal property within a distance of 500 feet from the place where it was removed.

SYPHON CULVERT.

At a place about 500 feet north of the lower quoins on the lift lock (No. 25) on this section, an inverted syphon culvert is to be built to pass the drainage from the east through under the new line of the canal.

It is to be 8 feet wide and 5 feet high inside, constructed of masonry laid in hydraulic cement mortar on a bearing surface of timber and plank; the whole to be fastened and secured in the manner herein described.

To enable the site of the culvert to be laid dry, a dam or bank formed of material taken from the excavation of the lock-pit or raceway, is to be made on the north and west sides of it and the water afterwards pumped out of the space thus enclosed.

The material used in forming these dams will be paid for in the excavation of that part of the works from which it is taken, and such portions of it as must subsequently be removed will be paid for in the excavation of a channel to or from the culvert or in forming the prism of the canal as may be required.

Contractors should, however, bear in mind that great care must be taken in preparing the seats of these dams, by the removal of all logs, sunken timber, roots or whatever is unsuited for the base of a water-tight bank, as they are not merely for a temporary purpose; but a considerable part of them will form the seat of the side banks of the canal.

The clearing out and preparing of the seats for these dams, the subsequent maintenance of the banks, unwatering of the culvert pit, and keeping it dry from the commencement of the works until their full and satisfactory completion, must all be embraced in the "bulk sum" stated in the tender for unwatering the works.

The pit for the culvert will be about 280 feet in length, 25 feet of which at each end must be made 25 feet in width, and between these points it is to be 18½ feet wide at bottom, the whole to be excavated to an uniform level surface at the depth of 11¼ feet below the top of the lower mitre sill of Lock No. 25. The sides to be made as nearly vertical as the nature of the material to be removed will admit; but as the contractor must assume the entire risk of all slides which may occur, and the whole expense of their removal, he will be allowed a slope of two horizontal to one vertical on both the sides and ends of the cut.

This allowance for slopes does not, however, apply to rock, if such be found in the bottom.

FOUNDATION TIMBERS—to be of pine 12 inches square, laid 6 inches apart transversely to the culvert or parallel to the canal, the spaces between them and at their ends must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed as subsequently described; or, if so directed, concrete must be used for that purpose.

For a distance of about 70 feet on each side of the centre line of the canal, two ranges of sub-sills 12 x 12 inches are to be laid in trenches cut for their reception, under the floor timbers. They are to be placed so that the centre of each range shall be 5¾ feet from the centre line of the culvert.

At every six feet, in both ranges and at places directly opposite each other, for the distance above stated, a tie rod one inch and a half (1½) or more diameter, is to pass vertically through the sill pieces, and be of a length to extend through the end of a cross-

binding piece which rests on the crown of the arch. Tie rods to be alternately of copper and iron, *i.e.* one half the number will be copper and the other half iron. These tie rods to have upset heads and large washers on the under sides of the sill pieces, and their upper ends are to be screwed and have nuts the full strength of the bar; the tops of these sill pieces when laid must be on the same level as the foundation, and form a fair bearing for the floor timbers; the spaces alongside of them must be well filled with puddle, and great care taken to keep the tie rods plumb until they are properly supported by the adjoining work.

Four ranges of sheet piles of 4-inch well-jointed pine plank, chamfered on the edges, 6 feet in length, are to be put in across the foundation and fastened to a floor timber extending 3 feet on each side, beyond the line of the walls; one at the inner side of the well at both ends of the culvert, and one within ten feet of the toe of the inside slope on both sides of the canal. Trenches of such a depth as directed are to be cut plumb on the proper lines for the sheet piles, and the places must afterwards be filled with the best description of puddle to the height of the adjoining ground.

The floor timbers when laid, after the spaces between them have been well filled with puddle, must be dubbed to an uniform surface to receive the plank, which is to be 3 inches thick, well jointed with a plane, and when being laid must be driven up close, break joints, and be fastened with white oak treenails, nine inches long and 1½ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber.

In case it is decided to put on a second course of plank between the side walls, the upper one will be 2 inches thick, and the lower course must be dubbed to a fair surface for it, the upper course to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber, on alternate sides of the plank.

MASONRY.—All the stone used in the culvert must be of the best class of approved sound and durable *grey limestone*, free from seams, drys, shakes, sand holes and other defects.

The water-way is to be made 8 feet wide between the side walls or abutments, which are to be 2½ feet high to the springing line of the arch; the latter is to be a circular segment of 2½ feet rise.

All the face-work of the water-way and wells at both ends of it are to be of stone of the dimensions, dressed and boucharded as herein described.

The abutments are to be 4¼ feet thick, carried up to a batter of one in twelve on the outer side, to within 15 inches of the crown of the arch. On the inner or face side, they may be made up of two courses, provided the upper course, in each case is formed into a skew-back for the springing of the arch—the nose or thin part of all of which stones must be at least eight inches thick, and increase gradually for a width of twenty-one inches to the angle suited to the radius of the curvature. At least one of these two courses must be thirty-one inches width of bed, and the other twenty-one inches, with headers not more than ten feet apart in each course. In all cases the beds and ends of the stones must be full, the arrises kept good, and the whole dressed and laid so that neither the horizontal nor vertical joints shall exceed one-fourth of an inch.

The arch stones must be fully twenty-one inches deep and be at least ten inches thick on the soffit, which must be dressed to correspond to the line of the curve, and the beds be dressed smooth and straight, so as to radiate truly for their full depth (21 inches), their end joints must also be kept full, and the various stones must be of such lengths as to break joints properly over and with each other. The courses must be divided in such

a manner that there shall be an equal number on each side of the key-stones, which must be at least ten inches thick on the lower side when fitted for the respective places they are to occupy.

In all cases the stones of the different courses of the abutments and arch must break joints over and with each other at least twelve inches, and throughout must be laid in full mortar-beds and driven up by means of a heavy wooden maul, to joints of one-fourth of an inch.

The arch must be formed on properly framed centres, the cost of materials, framing and fitting up of which, together with their complete removal when no longer required, must be embraced in the rate or price tendered for masonry.

For 70 feet on each side of the centre line of the canal the arch stones from the springing line upwards are to be secured to each other by means of wrought iron dowels one inch and a quarter ($1\frac{1}{4}''$) diameter and 3 inches long, let one inch and a half into the bed in the centre of each stone, and another in like manner put in at the end joints. The key-stones must also be fastened by dowels let down through checks cut in the beds of the stones, then moved a few inches, after which the checks are to be thoroughly filled with grout.

The abutment and spandrel walls are to be carried up to within fifteen inches of the crown of the arch, the upper stones of which for 70 feet on each side of the centre line of the canal must be in pieces of not less than ten square feet area, and be laid throughout to moderately close joints.

The well at the east end of the culvert is to be eight feet square at floor line; the breast wall $7\frac{1}{2}$ feet thick at bottom, is to have a batter of one in twelve on the inside, and be carried up plumb in the rear to within four feet of the bottom of the water-course, where a frost batter will be commenced and carried up with such an inclination as to terminate at the back line of the coping, which is to be $3\frac{1}{2}$ feet in width and must extend at least one foot into the wall on each side of the water-way.

The wall immediately over the eastern end of the arch, and also the side walls are to be $7\frac{1}{2}$ feet in thickness, and that part of each of them next the well is to be of dressed stone, all of which must be properly bonded at the angles and over each other. They are to be carried up to a batter of one in twenty-four on the face to the underside of the coping, and the rear sides of them are to be made vertical up to within five feet of the top bank or adjoining ground, where a frost batter is to be commenced and made to such an inclination as will strike a line $2\frac{1}{2}$ feet back from the respective sides of the well, at or near the surface of the ground.

From the point above mentioned upward, the walls are to be $2\frac{1}{2}$ feet in thickness, faced on both sides, and must be made up of stones the full width ($2\frac{1}{2}$ feet), to the underside of the coping, which is to be three feet wide on top, project three inches on each side, and have the top dressed so as to be one inch higher for a width of nine inches in the middle than on either face.

The top of the side walls to have an inclination outward of about one and a half horizontal to one vertical, except immediately over the breast wall where the coping is to be level.

The face-stones of the wells must be at least 20 and 30 inches depth of bed in the alternate courses and not less than $2\frac{1}{2}$ feet length of face in line of wall. In every course there must be headers of at least two feet length of face and $3\frac{1}{2}$ feet depth of bed, placed

not more than 10 feet apart from centre to centre. In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter, boucharded and the arrises kept good; the upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least nine inches back from the face. The whole to be dressed so that the horizontal and vertical joints between the stones when in place shall not exceed one-fourth of an inch.

BACKING—to consist generally of large well-shaped stones not less than 6 inches in thickness and three feet area of bed, laid level in full mortar beds and properly bonded throughout the wall.

The side walls and retaining wall at the outlet on the west side will be similar to those above described, but instead of a breast wall the bottom is to have a slope upward of about two horizontal to one vertical, and be formed of pitched stone 18 inches deep laid in cement mortar, and made 18 inches lower in the middle than at the sides.

The faces of the banks at both ends of the culvert for a distance of 25 to 35 feet or for such other distance as may be required, are to be protected by pitched stones 15 inches deep, laid dry, or in such other way as may be subsequently determined.

For the distance previously mentioned, 70 feet on each side of the centre line of the canal, a range of 12″ × 12″ timber is to extend along on both sides of the culvert resting on the large flat stones laid on top of the abutments. The tie-rods which pass vertically through the sub sills and walls are also to pass through these longitudinal timbers and cross-pieces of like dimensions, arranged in positions suited for that purpose.

For these cross-pieces checks three inches deep are to be cut in the crown of the arch, and the whole must be well bedded in mortar before the fastening nuts are screwed down.

The whole of the space between the line of canal bottom and the masonry, &c. of the culvert, for the distance above stated, is then to be made up with concrete prepared as herein described and firmly compressed in thin layers when put in place. On those parts of the culvert to be covered by the banks of the canal, the concrete will be 18 inches in depth over the crown of the arch. The spaces on both sides of the trunk of the culvert must be properly cleared out and filled with a good description of puddle well cut, trodden and pounded. As soon as the adjoining banks will admit, these puddle beds are to be made 3 feet in width, and be continued of that thickness to the height of the crown of the arch. The spaces between the puddle walls and the solid banks must be made up either with material hauled on in carts as provided for banks necessary to be made water-tight, otherwise the material must be laid on in thin layers and well pounded or beaten down and in this manner carried up also to the height of the crown of the arch. A puddle bed is then to be made 15 feet in width from the side of the concrete over the arch, and carried up to the canal bottom.

In rear of the side walls of the wells puddle beds are to be carried up—made two feet in width—as soon as the spaces between the walls and solid ground will admit; the adjoining banks must be well beaten and pounded until the space is sufficiently wide to admit of carts being used to haul on the material.

These puddle walls are to be carried up to within about seven feet of the natural or finished surface of the ground, when they are to be discontinued, and a space of 15 inches in rear of each of the walls of the wells and retaining walls is to be made up with gravel, small stones or quarry refuse, well rammed.

When making up the banks at and over the ends of the culvert the material must be hauled on in carts or waggons as described for other embankments, and great care must be taken to form proper connections between the old and new banks, as well as where they join on to the original ground, especially if the surface is inclined, when level benches must be formed as provided for in a preceding part of this specification.

SUPPLY RACE, &c.

For the purpose of admitting and regulating the volume of water necessary to supply the canal below the summit level, without passing it through either the guard lock or the lift lock, a raceway will be formed from a point about 250 feet south of the former, and continued northward to a point about 375 feet north of the lower quoins of the lift lock Its centre line will be parallel to that of the canal, and about two hundred feet to the westward, the line of its bottom will be 21½ feet below the coping of the lock; at this level it is to be 75 feet wide. Through the centre of it, above the weir, a channel 20 feet in width is to be excavated to the same depth as the bottom of the summit level. All the material excavated from it, not required for embankment in the immediate vicinity, must be hauled and placed so as to make up the banks on some part of the canal, or in forming part of the new public road where its line has to be changed. The side slopes in both cutting and embankment above the weir are to be two horizontal to one vertical.

REGULATING WEIR.—The entire width of the raceway will be occupied by the regulating weir, which is to be placed about 60 feet north of the range of the lower quoins of the lift lock, in such a position that its upper wings and piers can be utilized as bearings for a road bridge, and thus, together with the swing bridge over the lower end of the lock, form a continuous straight, level line of crossing at right angles to the canal. From the western end of this line a new road, having a gradual declivity, is to be formed on a course that intersects the present travelled road near the bridge through Marlatt's Pond.

The pit for the weir is to be made 82 feet in width, 50 feet in length and to a depth of 13 feet below the surface of the lower reach or about 25½ feet below the coping of the new lock. The material excavated from it, as well as from the sheet pile trenches, must be hauled and disposed of in embankment at one or other of the places previously mentioned as may be directed when the works are in progress.

The bottom to be trimmed level to form a fair bearing for the foundation timbers, which are to be of pine 12 inches square, laid transversely from 6 to 9 inches apart, resting on subsills, placed within line of the side walls, and on the bottom for their entire length.

The timbers may occasionally be in two lengths, provided the centre portion of the end of one piece enters horizontally 4 inches into that of the other, and underneath there is a binding piece 10 feet in length, secured by two wrought iron screw-bolts 1⅛ inches in diameter.

The sub sills are to be placed and arranged in like manner as those described for the foundation of the lift lock.

The spaces between the timbers as well as alongside of the sub sills are to be filled with the best description of properly made puddle, well beaten down, otherwise concrete either as a whole or in part is to be used as may be subsequently determined.

In the foundation of the weir there are to be four ranges of sheet piles, *i.e.*, one at the upper end, another at the lower end, one above and another below the breast wall;

they are generally to be of pine plank, 4 inches thick, 6 feet long, jointed, prepared and fastened, and the trenches cut for their reception made of the size, and subsequently well filled with puddle; the whole work connected with them to be executed in the manner described for those in the lock foundation.

The range of piles in line with the upper side of the breast wall of the weir must extend beyond the rear of the side walls and into the solid bank on the north side, and on the south side to the back of the masonry of the new lock, and in both cases to be carried up to water line of the upper reach.

FLOORING—to consist of two courses of approved pine plank. The first, 3 inches in thickness, is to extend over the whole area of the foundation of the weir and apron; the second course, 2 inches thick, is to be laid between the side walls for the entire space below the breast wall of the weir. They are to be well jointed, laid to break joints, and be fastened—the lower course with white oak treenails, and the upper course with pressed spikes,—and in every other respect the work connected with them must be done as described for the floor of the lift lock.

If rock suitable for a foundation is found at the proper depth, a timber bottom will not be required, and instead of sheet piles, stop-water timbers will be used as provided for under similar circumstances for the lock bottom.

MASONRY.—The weir will be formed by a wall of masonry, 50 feet in length, on both sides of the water-way, carried to the same height as the lock coping; and between these, transversely, will be a breast wall of a height adapted to the assumed low water level of Lake Erie.

Above the breast, two piers will divide the water-way into three equal spaces, for each of which there are to be three sluice-ways 4 x 4 feet.

The piers are to serve as bearings for a road bridge and for purposes connected with the regulation of the water. Immediately south of the breast wall and opposite each division of the water-way, is to be a movable bulk head, arranged in such a manner that there can be a constant flow of water over the top of it at any height the summit level may be kept.

The walls are to be built in the position represented on the general plan, and for the most part are to be of the dimensions herein stated; they must throughout consist of an approved class of gray lime-stone, free from seams, drys, sand holes and other defects, laid in full mortar on their natural beds.

It should be clearly and distinctly understood by parties tendering, that it is only those parts of the work between the ranges of sheet piles, at what is called the upper and lower ends of the weir, which will be measured, estimated and paid for as weir masonry.

SIDE AND WING WALLS—to be 8½ feet thick at bottom, face to be "rock work" with a batter of one in twenty-four; the stones to be at least 2 feet long in line of wall, 18 inches and 2 feet depth of bed in the alternate courses with headers 3½ feet depth of bed, and not more than 10 feet apart in every course; the whole to be dressed and laid so that the beds and end joints shall not exceed three-eighths ($\frac{3}{8}$) of an inch. The back of the walls to be carried up plumb to within five feet of the top; thence batter to the rear line of the coping, which is to be 3½ feet wide, except those parts occupied by the road bridge, where an offset of one foot is to be made for the ends of the stringers, opposite which the coping is to be 2½ feet wide.

BREAST WALL—to be 10½ feet in width at bottom, 4½ feet at top and 15½ feet high, built of stones 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep and not more than 9 feet apart; all of them must be dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side of the wall to be carried up plumb from an offset of 12 inches on the sill course, and the faces of all the stones dressed fair and smooth to receive the frame work of the sluices and bulk-heads; the lower side is to be "rock faced" work laid to a batter of about 5 inches to the foot rise.

There are, as above stated, to be nine sluice-ways through this wall, each 4 feet wide and four feet high, the top, bottom and sides of which are to be dressed smooth. The sills under them and lintels over them to be from 15 to 18 inches in height and 6 feet long, each dressed so as to lay to close and full joints and present a fair surface throughout the respective openings.

The piers between the sluice-ways, opposite each of the three divisions of the water way are to be 2 feet in width, and must be made of stones the full thickness, neatly dressed on both faces, and, when laid, bonded over and on to each other at least one foot.

DIVISION PIERS.—The piers to carry the road bridge, or those which divide the race-way, are to be about 5½ feet in width at the floor, carried up to such a batter on both sides that the top shall be 4 feet in width. These piers, coping excepted, may be made up of two widths of stone, provided there are double headers in each course not more than 8 feet apart. These piers are to extend three feet beyond the bottom line of the breast wall.

In the face of the side walls and on both sides of each of the division piers at about 6 inches above the upper side of the breast wall, checks are to be formed 12 inches wide and 6 inches deep at the top, increasing in depth according to the batter of the wall so that their backs shall be plumb. They are to extend from the coping down to 7 feet below the top line of the breast wall to admit of raising and lowering a movable bulk-head.

Near the upper end of the weir, checks 12 inches wide and 2 feet apart, 6 inches deep at the top, made plumb at the back for the full height of the walls, are to be formed in the face of the wings and on both sides of each of the division piers for the reception of stop-timbers. Below these checks a cross wall 4 feet in width and the same height as the sill course of the sluices is to be built of block stone the full width. The stones are to be secured to each other by dowels and vertical bolts in such a manner as may be required.

The arrises of all the face stones on both the upper and lower sides of the breast wall—the division piers, the sills, lintels, piers and sides of the sluice-ways must all be kept good, and the whole dressed and laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

COPING.—The breast wall coping must be at least 16 inches high and 4½ feet wide on top, increasing in width downward to the batter of the wall. The lower bed and joints of each stone must be kept full throughout, and the top dressed fair, so as to have a declivity of one inch toward the up-stream side. It is to be in lengths of not less than three and a half feet, be connected with dowels at the joints, and secured with bolts to the course underneath.

The coping stones of the side walls and division piers must be at least 12 inches in thickness, have full beds and joints and be neatly boucharded on top.

In addition to the range of sheet piles to be placed in line of the breast wall, a counterfort of masonry, 4 feet thick and 6 feet in length, is to be carried up in connection with each of the side walls to within 4 feet of the top of the coping.

BACKING,—to be of a similar class of stone laid in like manner as described for the rear part of the lock walls.

The whole of the weir masonry must be laid in the best hydraulic cement mortar, mixed and prepared as stated for other parts of the works.

A puddle bed 3 feet in width is to be carried up in rear of the side walls to the full height of the summit-level.

The material used for this purpose as well as for the puddle between the foundation timbers and for the sheet pile trenches must be of the best and most suitable kind that can be found on the section or in the vicinity of the works.

SLUICE GATES—to be built of the best quality of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to $3\frac{1}{2}$ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths ($\frac{7}{8}$) of an inch in diameter, passing through the gate, and to have straps of wrought iron 3 inches wide and three-eighths ($\frac{3}{8}$) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush and fastened, at distances not more than six inches apart, with rivets $\frac{1}{2}$ an inch in diameter countersunk into the straps. The top plates are to be $2\frac{3}{4}$ inches deep, and those at the bottom $6\frac{1}{2}$ inches deep, each to have a flange from the centre outwards on opposite sides.

They are either to be made the full height of the opening in the breast wall, or the upper part of the opening is to be closed up and the height of the gate diminished, as may be subsequently determined. In either case the gates are to revolve on the centre, or pivots working into the bottom plates of the gates, and on the top of each a disc of steel or hard brass is to be placed and have a brass collar and lining. The pivots are to be $3\frac{1}{2}$ inches diameter, connected with plates 9 inches square and 2 inches thick let into the sills of the sluice-way and secured to them by fox-bolts.

The gates are to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key-bolts to the piers and lintels of the sluice-way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed.

The turning rods are to be of wrought iron of sufficient length to pass through the the gates and stand six inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates, and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected ,with racks on the platform, made so as to secure the gate in the position required.

The bulkheads are to be of pine timber 12 inches square, planed, jointed and secured to each other with bolts passing vertically through them having suitable tightening nuts and washers. As a means of raising or lowering them, a rod will be attached at both ends near the recesses in the walls, which will work through a brass matrix fitted into castings secured to the timber work, and the upper ends of the rods are to have bevel spur-wheels keyed on to them to gear into pinions on crank shafts attached to the bridge.

If considered desirable to work all the three gates in each division of the weir at one time it is to be done in a similar way to that above stated for the bulk heads. The prices tendered for the different items of iron work are to be understood as being applicable in either case.

ROAD BRIDGE—to be formed of stringers of pine timber 12 × 12 inches, placed 2½ feet apart; they are to rest on the tops of the piers and in the offset made by the coping on the side walls and are to be fastened to the masonry with fox-tailed screw-bolts one inch diameter. The outer stringers to be double with distance pieces of oak 12 × 12 × 5 inches between them placed about 5 feet apart and connected with screw-bolts one inch and a quarter diameter.

The covering to be of 3-inch plank of a length to reach across the bridge; they are to be fastened with 7-inch pressed spikes.

On each side of the bridge a guard railing is to be formed by posts placed about 4 feet apart, checked into the outsides of the double stringers and fastened with ⅝" screw-bolts. The posts are to be tenonned and mortised to receive the rails and diagonal braces, and when properly framed they are to be connected with white oak pins; the posts, rails, and braces to be stop-chamfered. On both sides of the road where the ascent to the bridge over the weir is made, a rail fence similar to that above described, but with cedar posts, must be put up if directed.

RACEWAY MASONRY.—From the lower end of the regulating weir to where the race-way enters the canal north of the lift lock, the sides of it are to be formed of "random coursed masonry" *i.e.*, both beds of the face stones must be nearly level when laid, but continuous courses will not be required.

At the south end the walls are to be the same height as the regulating weir, thence they are to correspond with the line of the adjoining banks. The foundation for them must be sunk to about the same level as the bottom of the reach below the lift lock.

They are to be 2½ feet wide on top and have a batter of one and a half (1½) inches to the foot rise on the face side, and on the rear side increase at the rate of 3 inches to the foot for the first 5 feet from the top, thence downward they are to be plumb. At the back of the walls and in connection with them counterforts 4 feet long and 3 feet deep are to be carried up 16 feet apart to within 5 feet of the top bank.

The whole of the walls must be built of sound, durable, flat-bedded and well-shaped stones of an approved class, not less than 6 inches thick and at least 3 feet area of bed, laid so as to form proper bond over and with each other in both front and rear.

Headers of at least 3½ feet depth of bed must be placed not more than 7 feet apart in every course.

The beds and ends of the stones must be hammered, picked or scabbled so as to lay to such joints as may reasonably be called for in the best class of undressed random coursed masonry; no pinning will be permitted.

The coping stones must be 2½ feet wide on top, increasing according to the batter on both sides of the wall, and not less than 10 inches thick nor less than three feet in length. The faces of all the stones must be hammered or scabbled to lines corresponding to the position they are to occupy in the work.

In rear of each wall (if so directed), a space 15 inches in width and for a depth of seven feet below the surface is to be made up with small stones, gravel or quarry waste well rammed.

The whole of the masonry of these walls is to be laid in hydraulic cement mortar prepared as previously described, and all the different courses of stones grouted up as the

work progresses. The abutments for the towing-path bridges at both ends of the raceway are to be of a similar class of work, the piers for which are to be faced on both sides. Contractors are, however, hereby informed that the piers and abutments of these bridges will be classed, measured and paid for at the same rate as raceway masonry.

Where the new line of canal crosses the public highway either at this place or at the road north of Beaver Dams Creek, the contractor must provide a convenient, safe and satisfactory means for the public travel to pass before the present road at either place is interrupted or in any way or shape interfered with.

These temporary crossings must be made easy of access, be satisfactorily maintained during the progress of the works, and have such fences put up at and alongside of them as may be required to guard against accident, and everything done that may be required to render them safe and satisfactory to the public. All of which must be embraced in the respective bulk sums stated in the tenders for these purposes.

It should be clearly and distinctly understood that he (the contractor) shall be held strictly and legally liable to individuals as well as to the public for any detention, loss or accident that may result from the means of crossing provided by him being either defective, unsafe or inadequate for the public travel.

At places where the present macadamized road is interfered with by the works a new and convenient road will be made in its stead, on which is to be laid a covering 12 inches in depth of an approved class of broken stone, the first six inches in depth to consist of stone broken to cubes of about four inches, and the upper six inches must be broken to such dimensions that every piece in its greatest length could pass through a ring two inches in diameter. The macadamizing to be properly shouldered up and side ditches to be formed on one or both sides of the road of such dimensions and with such an inclination as may be required for efficient drainage.

CULVERT AT BEAVER DAMS.—To pass the drainage of the Beaver Dams Valley, an arched culvert of similar sectional area to that under the present canal will be constructed under the new line. It will be about 350 feet long, built of masonry on a foundation of timber and plank placed at a depth of 11 feet or more below canal bottom, and may be constructed either with two small archways or in one arched opening of larger dimensions as may be determined by the nature of the bottom.

It may be stated, for the information of parties tendering, that the pit for this culvert will be comparatively shoal, and for which the same rate per cubic yard will be allowed as for excavation on the section. The floor for it will be laid, sheet piles put in, and the masonry of the bench walls, arch, etc., will be of a like class to those of the syphon culvert described in a preceding part of this specification, except that there will be no wells at the ends, no dowels in the arch stones, no vertical tie rods in the masonry, nor horizontal timbers on the top of the arch.

It is, therefore, to be clearly and distinctly understood that the prices tendered for the masonry and other items of work are to remain at the same rates whether the culvert be built in two small arches or in one arch of larger dimensions.

Contractors when tendering should clearly and distinctly understand that all the works connected with the formation of the canal through Marlatt's Pond, the construction of the piers and abutments for the Welland Railway bridge, or for the temporary divergence of the line, must be done without in any way or shape interfering with the safe and efficient working of the railway or the traffic upon it.

The carrying out of these conditions will be rigidly insisted upon, a fact which should be borne in mind by parties when tendering for the work, and also that the contractor will be held strictly and legally liable to the proprietors of the railway, the public, or to individuals, for any loss, damage, accident or detention which may be sustained through his acts, whether the same arise from oversight, neglect, or from a desire to proceed with the works expeditiously, or from any other act or cause whatever.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel through Marlatt's Pond, or of the disposal of excavated or dredged material, or in proceeding with any other part of the operations connected with the works, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must, further, use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed drawings, arranged, modified and adapted to the circumstances and the locality, for all such parts of the structures as may be considered necessary for the full understanding of the design, will be furnished as the works proceed.

If any alterations be rendered necessary by any cause, or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, store-houses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the fulfilment of the contract satisfactory security will be required, by deposit of money, to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the fullest advantage will be taken of the time when the water is out of the canal between December, 1877, and the opening of navigation in April, 1878, to urge forward to completion all such works as would in their execution be retarded or in any way interfered with when the water in the present canal is at its usual height. To be certain of this, all stone, timber and other materials required for the works through or in the vicinity of Marlatt's Pond must be provided and delivered this autumn, all such works done and such arrangements made as will fully satisfy the Department of Public Works that every effort has been made and continues to be made as will warrant the conclusion that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 1st day of June, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 3rd August, 1877.

APPENDIX No. 12.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTIONS Nos. 19 *and* 20 *of the Enlargement.*

These sections include the formation of fully one mile and a quarter of new line between Thorold and Allanburg; the enlargement of the original canal for fully one quarter of a mile through the latter village; thence the enlargement of the present canal for a distance of about one-fifth of a mile to the south end of the section, when a strip from 50 to 60 feet in width is to be taken off the east side of section No. 21, at its north end, running out to nothing within a distance of 500 feet, making the aggregate length nearly one mile and four-fifths.

As the whole is to be let in one contract, it will be treated in this specification as forming only one section, the boundaries and general line of which are represented on the plan exhibited and marked on the ground.

It embraces the works connected with forming two small arched culverts under the new line; the construction of abutments and piers for a swing bridge to serve as a road crossing at Allanburg; building a retaining wall on the west side of the new line from the head of the guard gates to 300 feet below the foot of the lift lock, a distance of fully 1,000 feet; the extension of the north wings of the guard lock to form the abutments for a swing bridge across the present canal; the construction of a supply weir on the west side above the guard lock for the present navigation, and such other works as are herein described or the contractor may be called upon to execute.

The canal will generally be made 100 feet wide at bottom when sunk to the level of 3 feet below the top of the mitre sill of the present lock at Port Colborne; side slopes in both excavation and embankment to be two horizontal to one vertical.

All permanent structures are to be placed sufficiently low for a depth of 15 feet water in the reach, or fourteen feet on the entrance lock sills at the assumed low water of Lake Erie, which is eleven feet on the sills of the present lock at Port Colborne.

The centre line of the channel and the sites of the different structures will, for the most part, be as represented on the general plan exhibited and marked out on the ground; the Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line as much as two hundred feet, either to the right or left of that shown, and of altering the position of any one, or all, of the structures as much as thirteen hundred feet either upward or downward from the place indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution of the price tendered for the respective items of work.

CLEARING, GRUBBING, MUCKING, &c.—From the spaces to be occupied by the banks of the canal, or wherever a water-tight bank is required to be made, all trees must be cut down—stumps, roots and bushes thoroughly grubbed, and the whole, together with logs and brush of every description, must be removed or burned as may be directed, but in either case without damage to adjoining property. Trees close to the line of the canal, which by falling might injure the banks or interrupt navigation, must be cut down and removed, if directed. All the clearing, grubbing and removal of brush, logs, &c., &c., must be completed before the work of making up banks is commenced.

The material to be excavated on about six-sevenths of the whole length of the section will chiefly be clay, some of which will, in all probability, be of a hard nature. For about two-thirds of a mile at the north end of the section the excavation will considerably exceed the quantity of material required for embankment, still part of the material must be hauled fully 900 feet. On the next four-sevenths of a mile the quantity of excavation and embankment will be nearly equal; the haul on this part of the line will vary from 300 to 2,500 feet and applies to about one-fourth of the entire excavation.

For about a quarter of a mile where the line passes through the village of Allanburg, various kinds of material have to be removed, consisting of clay, dry masonry, chiefly of small stones, old timber framed and otherwise, old lock gates, sunken timber, roots, etc., the greater part of which have to be taken out and hauled to deposit ground, which is from 400 to 1,000 feet distant from the place where the widening and deepening has to be done.

South of the guard lock, the material to be excavated will chiefly be clay, that must be removed by machinery and deposited partly on the east side and part on the west side of the canal.

In all cases where a bank adjoining the canal has to be made over sloping ground, whether the inclination be parallel to the canal, at right angles to it, or at any other angle, the seat must invariably be either cut down so as to give a level bearing, or be made into benches, each of which must of itself present a horizontal surface of sufficient width to admit of a suitable connection being made, and so as to guard against any tendency to slide.

When the ground where a bank is to be formed is below water level, the surface must be removed for such a width in the centre of that space, or for the entire width to be occupied by the bank if required, or for such a depth as may be directed; the sods, muck, rubbish, brush, roots, or loose earth thus removed must be hauled and placed at such a distance from the banks as the circumstances may require.

For preparing the seats of banks, the material removed will be measured in the "solid," and the quantity paid for at the same rate as for excavation of the section

which rate should be clearly understood to include the cost of handling all kinds of material necessary to effect the object, and the removal of the same to such places within the limits of the section or elsewhere, as may be directed.

Parties tendering should bear in mind that as the water will be drawn off that part of the canal below the guard lock at Allanburg in December next (1877) or as low as circumstances will permit, and be allowed to remain out, (surface water, leakage and drainage excepted) until April 1878, the contractor will be called upon to have all such arrangements made and materials provided for proceeding expeditiously with those parts of the works between the head of the guard gates and where the line leaves the original canal south of the Holland Road, during the time that the water is thus lowered.

The admission of the supply, to the present canal, floods a considerable extent of the space mentioned, *i.e.*, between the guard gates and the Holland Road; the present mode of supply cannot, however, be interfered with until there is a certainty of having other means of admitting the necessary volume of water provided in time.

It is therefore indispensable that the regulating weir above and on the west side of the guard lock should be built this autumn, or at least the largest portion of it, so as to be certain of its full completion by the opening of navigation in the spring of 1878.

A dam is to be built between the salient point above the head of the present guard lock and the east bank of the canal, of sufficient height to keep the water out of the old or original cut which is now to form the new line.

A dam must be also made above the guard gates on the present line, which it is thought may be advantageously done without endangering existing works, by the contractor providing tarpaulings sufficiently large to cover the whole surface of the gates and extend several feet along the sides of the recesses and the bottom at the place where they are to be used, or the adoption of such other plan as will ensure a staunch dam with the use of the least quantity of clay, and with a view to the speedy clearing out of the channel to the required depth the following spring.

The present regulating weir is to be removed, for which a rate per cubic yard is to be stated in the tender; this rate to include hauling and placing the stones, or at least such of them as are sound and fit for use, in the new work, in a position where they can be advantageously got at, and hauling and placing all refuse in the spoil banks, as may be directed.

As previously stated the materials to be removed in forming that part of the channel opposite the guard lock, down to the Holland Road is of various kinds, the nature of which contractors are recommended to ascertain on the spot before "tendering" in order to avoid further misunderstanding. For this part of the line, or between a point 200 feet south of the guard lock and the south side of the Holland Road, parties will be required to state the rate per cubic yard for which they are willing to form a channel of the width previously stated and to a depth of 4¾ feet below the top of the mitre sills of the present lock at Port Colborne; including clay, stones and all other kinds of material found in side walls, foundations or in any way connected with the old locks, lock gates, old timber work, framed or unframed, connected with the original tail races; removal of old scows, sunken timber, saw logs, roots, saw-dust, bark, slabs, stone of all kinds, and all rubbish found within the line of the canal or its banks, or the removal of which is necessary to render the base of the banks water-tight, are all to be embraced in the item of excavation, which must also include hauling and depositing the material within the limits previously mentioned.

For all excavation south of a point 200 feet above the guard lock, parties tendering will be called upon to give a separate rate, which must include placing about one-half of the material on the east side, and the other half on the west side, within a distance of 500 feet along the canal from the place where it was removed, and at such a distance back from the centre or water line as subsequently described.

TOWING PATHS—to be formed on both sides of the canal, both in cutting and embankment. They are to be of a height suited to the Grand River level; in each case 15 feet in width on top, have an inclination outward, of about twelve inches, to a ditch formed at all places where the bank in rear of it is of a greater height. The ditch to be two feet or more in width at bottom, and have such an inclination as will carry the surface water freely to the culverts which pass under the canal, or to such off-take drains as circumstances may require to be formed.

In connection with them, where necessary, wells are to be sunk, for which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal, two feet or more below the assumed level of Lake Erie. These wells are to be from two to three feet square, and the culverts from them from 15 to 24 inches square; they are to be built of rubble masonry, laid in cement; the bottoms of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least six inches under the walls on both sides, the covering of the culverts to be of flat stones, of a length which will bear at least six inches on the side walls.

BACK DITCHES.—To carry off the surface water, and such other natural drainage as it may be necessary to provide for, ditches are to be formed on both sides of the canal, at the places and of the dimensions required; care being taken that any present means of drainage shall not be interfered with before another outlet is provided. For any damages that may arise from this cause, whether the result of inattention or otherwise, on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

Wherever it may be found necessary to spoil material removed from the cuttings, whether it be from its unsuitableness or distance from where it can be advantageously used, the bank must be kept back at least 20 feet from the edge of the cut, and if placed on ground higher than the towing-path, the material must be kept at least 10 feet back from the top edge of the slope.

The tops of spoil banks must invariably be made of such a height and width as may be directed, and their upper surface have a slight inclination outward from the canal.

BANKS, &c.—All the suitable material excavated from the prism of the canal, race-way, foundation pits, &c., must be hauled and placed so as to make up the banks of the canal through low ground in rear of structures or wheresoever required within the distances or limits before mentioned. In all cases the best material must be placed on the side next the canal, and coarse, inferior or less suitable kind must either be used to form the outer parts or removed entirely beyond the line of the banks and spoiled where directed.

When making up the banks of the canal or embankments at and in rear of structures and at all places where a bank is to be formed through or alongside of ground that is lower than the canal surface, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS,—when necessary to be made for the security of any of the banks, must be carried up at the same time as the banks are formed. They must invariably be made of the best description of material for that purpose that can be obtained at any place on the section, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock." The former to embrace all kinds of material found in cutting the canal to its full width and depth within the northern and southern boundaries of the section, excavating lock and wier pits, bridge seats, &c., except absolutely connected "quarry rock," and detached stone or boulders containing one-third of a cubic yard and upward.

The prices tendered for these items must cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments in rear of structures or where required on the section, forming spoil banks at the places and in the manner directed, grading towing paths, and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications. But as the price per cubic yard for each division of the work will be an average of the whole of that class, payments will only be made according to the comparative value of the work, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been executed and completed, the aggregate amount shall be the same as when the respective total quantities are calculated and extended at the prices stated in the contract.

SIDE WALL.—On the west side of the new channel, from a point near the head of the guard lock to about 300 feet below the lower end of the present lift lock, a retaining wall of "random coursed masonry" is to be built, *i.e.*, both beds of the face stones must be nearly level when laid, but continuous courses will not be required.

The foundation for this wall is to be $5\frac{1}{3}$ feet below the top of the mitre sill of the present lock at Port Colborne, and as its top will be on the same level as that of the adjoining locks, the wall will be about 26 feet in height. If the bottom at the depth stated is found to be of a solid and compact nature, the masonry will be commenced upon it by using large flat-bedded stones for the first and second courses.

In case the bottom is soft or of a nature that requires a more uniform or continuous bearing surface to be formed, a platform consisting of five or more timbers, each 12 inches square, will be laid longitudinally underneath the wall for a part or for the whole length of it as may be required; the spaces between the timbers to be filled with a good description of puddle, or with concrete, as may be directed.

The wall is to be 7 feet thick at bottom carried up to a batter of one-eighth horizontal to one vertical on the face, made plumb in the rear to within five feet of the top, when it is to batter to the rear line of the coping, which is to be $2\frac{1}{2}$ feet wide on top.

At the back of the wall and in connection with it, counterforts six feet long and three feet deep are to be carried up fourteen feet apart to within 5 feet of the top.

The whole of this wall must be built of sound, durable, flat-bedded and well-shaped stones of an approved class; those for the face work must be at least 18 and 28 inches depth of bed in alternate courses, all of which must be not less than 9 inches thick and two feet long in line of wall, and have headers in every course of at least 2 feet length of face and $3\frac{1}{2}$ feet depth of bed, placed not more than 12 feet apart from centre to centre.

The beds and ends of the stones must be hammered, picked or scabbled, so as to lay to such joints as may reasonably be called for in the best class of heavy undressed random coursed masonry, and be bonded at least nine inches over and with each other on both face and rear. The backing stones must be at least six inches in thickness and three feet area of bed, laid level in full mortar beds and properly bonded throughout the wall; they must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the back line of the wall.

The coping stones to be 2½ feet in width on top, increasing downward according to the line of the batter on the respective sides of the wall; they must be at least 10 inches thick and not less than 3½ feet in length. The whole of the masonry of this wall is to be laid in the best hydraulic cement mortar, prepared as subsequently described, and every course must be fully grouted up as the work progresses.

In rear of the wall, at such places as may be directed, a space 15 inches in width and for a depth of five feet or more below the surface is to be made up with small stones, gravel, or quarry waste well rammed.

For the accommodation of the public travel in the vicinity of Allanburg two swing bridges must be constructed—one across the present canal immediately north of the guard gates, and the other over the new channel; both of which are to be on the line of the public highway known as the Canby Road and nearly in the position indicated on the general plan.

The centre line of the new canal at this place is to be kept as far to the westward as the structures on the present canal will admit, so as to limit, as far as practicable, the widening on the east side and, at the same time, allow the respective lines to the southward to approach each other at the least objectionable angle.

Bridge Works on New Line.—The water-way at this place is to be in four divisions, the two centre ones of which are each to be 46 feet wide and form the navigable channels. The piers and east abutment are to be of masonry laid in hydraulic cement; built chiefly in the form, of the dimensions, and in the manner herein described or as may be subsequently directed.

At the place where the bridge works are situated, a space 220 feet in length and 170 feet in width is to be sunk to the depth of five feet below the top of the mitre sill of the present lock of Port Colborne; the ends and east side of which are to be made to a slope of about one horizontal to one vertical. The material excavated from this space, as well as from the seats of the piers, which are to be sunk one foot and a half (1½) lower, must be hauled and deposited where directed within the distance previously stated. Contractors, when tendering, should bear in mind that it is only the widening beyond the side slopes and the deepening below ordinary bottom line of the prism of the canal which will be measured, estimated and paid for as bridge pit excavation.

The centre and rest piers of the bridge are to be as nearly as possible parallel to the centre line of the canal, the former to be 16 feet square, and the latter 16 feet in width and 9 feet thick at top. Through each of them an arched culvert, 6 feet wide and 8 feet in height, is to be made on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least six inches under canal bottom, and in each case they are to have a batter of one in twenty-four.

The arch-stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth (¼) of an inch. The

bottom part of the arch, or water-way, is to be of dressed and properly-jointed stones, of a size that two of them will make up the width of the opening, and the end of each pass 15 inches under the wall, the second course to project one foot into the opening on each side, and the third to project inward 6 inches.

The face stones of the piers to be two and three feet depth of bed in alternate courses, with headers in every course 4½ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stones are to be kept full, and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case must invariably be made up with flat-bedded stones, not less than 4 feet area of bed, and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch, and the vertical joints be not more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge, when in position, are to be 10½ feet thick at bottom, the sides of which are to be parallel to the canal, and the ends to be at right angles to the face of the pier. They are to be faced on both sides, and throughout be of a like class of material and workmanship, and the foundation for them be formed at a like depth as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty-four.

At four feet from the top of these piers, or at such other height as may be required, offsets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, the foundations of which are to be laid at five feet over canal bottom, or at such other level above or below that point as circumstances may require. They are to be 7½ feet or more in thickness, carried up to a batter of one in twelve on the face to the water line, and made plumb in the rear to within four feet of the top, thence the wall will diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized, well-shaped stones, laid level in full mortar beds, and properly bonded throughout the wall.

The centre pier, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

The retaining wall on the west side of the new line will form the west abutment for the swing bridge. The foundation for the one to be built on the east is to be laid either at canal bottom or at such other level above or below that point as circumstances may require; it is to be 7½ feet or more in thickness, carried up to a batter of one in eight on the face to the water line, and made plumb in the rear to within 4 feet of the top, thence the wall will diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing to consist of large-sized, well-shaped stones, laid level in full mortar beds, and properly bonded throughout the wall.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers, for the seats and rests of the bridge, and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6

feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout, and dressed so as to lay to joints not exceeding one-fourth of an inch; and the top side must have a fair surface, be neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed; the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones, for a width of four feet, is to be twenty-four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge will be 10 inches in thickness at the centre of the road, curved on top, so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At the two east corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward—one of which, at each end of the bridge, must be recessed and hollowed out to receive machinery.

The wings of the east abutment are also to be carried up to the same height as the parapet piers and finished with coping, as indicated on the plans.

The walls above and below the east abutment, for a distance of 40 feet or more, are to be of masonry, arranged to wind gradually round to meet the line of the slope on the respective sides.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutment they are to be laid either longitudinally or transversely, as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete, as may be directed.

The covering plank to be of pine, three inches thick, and must be fastened to the timbers with 1¼-inch white oak treenails eight inches long.

SHEET PILES—of 4-inch pine plank are to be put in, or driven on all sides of the piers if the officer in charge considers it necessary.

CRIB WORK.—Between the centre and rest piers, as well as above and below them, crib work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work. The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 16 feet wide at top, increasing downwards on both sides at the rate of one in twenty-four; and through the middle of them, longitudinally, a clear water-way must be formed of such dimensions as may be directed.

Transverse openings are also to be made in the cribwork adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings give an area equal to at least that of the arch ways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge there are in each case to be left two openings on the upper and two on the lower sides. The sides of these openings are to be formed, framed and secured in like manner as the face work of the cribs, the bottom to be of 3-inch plank, well fastened with pressed spikes, and the top to be formed of pieces not less than 10 inches thick, and of a length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$-inch diameter is to be driven through the dovetail.

Cross Ties—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be midway between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides so as to stand eight inches at the neck and 11 inches at the outer end.

Under the head of each tie in the joint between the courses immediately below it, a block $1\frac{1}{2}$ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

Longitudinal Ties.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them and be secured by bolts of similar dimensions in like manner as described for the transverse ties into which they are to be notched, and fastened at the crossings by means of white oak treenails two inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water-line. There are to be three ranges on a side, that is to say:—one at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be four inches thick and 10 inches in width, fastened from the inside with 10-inch spike, five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from eight to ten feet or more, but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than three feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the sides next the channel.

The whole interior of the crib work, except the water-ways, to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide-piers there are to be two ranges of wale-timbers of white oak 6 x 12 inches, the upper range to be fastened by means of screw-bolts half an inch diameter, having upset heads let into wrought iron washers counter-sunk for them. The other range to be seven feet lower and fastened by rag-bolts $\frac{3}{4}$ of an inch diameter, having similar heads and washers to those in the upper range.

The wale-pieces to be put on in lengths of from 24 to 40 feet, their upper edges are to be chamfered, and, where they connect, their ends are to be scarfed, covered with boiler-plate and secured as directed.

For the protection of the structure and piers, three clusters of piles are to be driven within range of the centre pier at suitable distances above and below it; they are to be connected by means of thorough-bolts, straps, &c., and stand one foot or more over the cribs, &c., as may be required.

FENDERS—are to be constructed on the land sides of both the water-ways extending for some distance above and below the bridge, as represented on the general plan. They are to be formed by means of piles, caps, anchor timbers and wale-pieces, all of white oak timber. The piles to be not less than 11 inches diameter at the small end, driven from six to ten feet into the bottom, three in a group, at about 12 feet from centre to centre and one at the middle of each anchor timber when they exceed 25 feet in length. The caps are to be formed of two pieces each 6 x 10 inches arranged about eight inches apart and checked obliquely to receive a dovetail formed on the head of the piles, to each of which they will be secured with wrought iron screw-bolts $\frac{7}{8}$ of an inch in diameter, having upset heads and cast iron bevel washers let flush into the out-side cap-pieces.

Immediately under the caps the anchor timbers will connect with a dovetail the outer piles, and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter; they will bear on the inside pile of the group and the ends extend to the outside of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same or inside piles with a screw-bolt of one and one-eighth ($1\frac{1}{8}$) inch round iron, having upset heads and washers sunk flush as described for the cap-pieces. Where the wale-pieces are scarfed they must be secured to the outer piles with screw-bolts $\frac{7}{8}$ of an inch diameter with nuts, heads, &c., as described for the others. At seven (7) feet below the top of the cap-pieces another range of waling 8 x 10 inches is to be put on, fastened throughout with bolts in like manner as for the upper tier.

The outer ends of the anchor timbers must be let into the banks for such a distance as may be required and be secured to mud sills or cross timbers.

MORTAR.—The masonry of the bridge piers, side walls, regulating weir, culverts, etc., must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings, provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about $1\frac{1}{2}$ of clean, sharp sand to 1 of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course must be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

CROSSING OVER PRESENT CANAL.—In continuation of the road crossing over the enlarged canal, another is to be formed to the north of the guard lock, the abutments of which are to be built in such a position that their centre line shall be about 75 feet north of the gate quoins, and their respective face lines stand about two feet back from the range of the side walls of the guard lock.

The one on the east side which is to form the turntable pier, is to be 16 feet square and must be commenced at least 6 inches below canal bottom. The toe abutment is to be 23 feet long and 8½ feet thick at bottom; in the centre it is to be connected with a counterfort 3 feet thick and 6 feet long. On the west side the wings of the abutments are to be carried up from about 6 feet over canal bottom, to the same height as the parapet piers which, at the two west corners of the bridge, are to be built 4½ feet square at base, diminishing upward; one of them must be recessed, and hollowed out to receive machinery.

The wall to form the seat for the heel of the bridge must be commenced at least six feet below the surface of the adjoining ground; small piers are also to be built in positions that will form a rest for the bridge when open.

The masonry of the abutments is to be of stone of the class and dimensions, dressed, cut, laid in cement mortar and the work finished in every way as described for the piers and abutments of the adjoining bridge works on the new part of the canal, except that there will be no archway through the pivot pier.

CRIB WORK—to be put in on the north side of the abutments extending downward about 30 feet; the north end of them in both cases is to be made oblique, that is to say, the back part of the crib work is to be longer than that on the channel side.

Between the south side of the abutments and the north wings of the guard lock, piles are to be driven to support the fender timbers and wale pieces, the south ends of which are to be let into checks cut in the wings of the lock.

Fender timbers are also to be placed to the north of the crib work, secured to piles driven for that purpose and to anchor timbers let into the bank. The works generally are to be done and protected in a similar manner as previously described for those connected with the bridge on the new canal.

The superstructure for both the fixed and movable parts of these bridges, as well as the machinery for working the latter, will be made a separate contract.

Parties tendering should bear in mind that all the masonry in the abutments for the bridge crossing of the present canal must be built, completed and protected between December, 1877, and the opening of navigation in April, 1878, or during the time when the water is drawn down for this and other purposes.

It is proper to state that, although the water is to be shut off at the guard gates, there is every probability that there will be considerable leakage to contend with; the disposal of which must be provided for in the bulk sum stated in the tender for unwatering the foundations of the abutments, etc.

In case it becomes necessary to shut off the water at the gates of the lift lock, in order to keep the intermediate level at a greater height, and thus divide the head of water, the work is to be done in a similar way as provided for the tightening of the guard gates, and if directed by the Department of Public Works, must be done by the contractor for a like bulk sum as tendered for that purpose.

In the event of the latter course having to be resorted to, it may be found necessary to form the bridge abutments for the crossing of the old canal of crib work, and to use the stone provided for that purpose in the regulating weir or in other works connected with the new canal, and for which they will in that case be measured, estimated and paid for as masonry in the wall in which they are used, and not otherwise.

SUPPLY WEIR.—To provide for passing the volume of water required for the present canal, a weir is to be built on the west side of about 200 feet south of the guard gates, near the place indicated on the general plan.

The weir is to be placed so that on its upper wings a towing path bridge can be formed, the front edge of which shall be at least as far to the east as the west line of the present track-way.

The pit for the weir is to be made 56 feet in width, 50 feet in length and to a depth of 25½ feet below the coping of guard lock. The material excavated from it, as well as from the sheet pile trenches, except what is to be used for puddle, embankment in rear of the walls, etc., must be hauled and disposed of on low ground in the vicinity, within a distance from 300 to 600 feet, care being taken that the seats of spoil banks are benched when the surface is inclined, as provided for other banks on the section.

The bottom to be trimmed level to form a fair bearing for the foundation timbers, which are to be of pine 12 inches square, laid transversely from 6 to 9 inches apart, resting on sub sills, placed within line of the side walls, and on the bottom for their entire length.

The spaces between the timbers as well as alongside of the sub sills are to be filled with the best description of properly-made puddle well beaten down, otherwise concrete either as a whole or in part is to be used as may be subsequently determined.

In the foundation of the weir there are to be four ranges of sheet piles, *i.e.*, one at the upper end, another at the lower end, one above and another below the breast wall; they are generally to be of pine plank, 4 inches thick, 6 feet long, jointed, prepared and fastened, and the trenches cut for their reception made of the size, and subsequently well filled with puddle; the whole work connected with them to be executed in the manner described for those in the lock foundation.

The range of piles in line with the upper side of the breast wall of the weir must extend beyond the rear of the side walls and into the solid bank on the north side, and on the south side to the back of the masonry of the new lock, and in both cases to be carried up to water line of the upper reach.

FLOORING—to consist of two courses of approved pine plank. The first, 3 inches in thickness, is to extend over the whole area of the foundation of the weir and apron; the second course, 2 inches thick, is to be laid between the side walls for the entire space below the breast wall of the weir. They are to be well jointed, laid to break joints, and be fastened—the lower course with white oak treenails, and the upper course with pressed spikes.

MASONRY.—The weir will be formed by a wall of masonry, 50 feet in length, on both sides of the water-way, carried to the same height as the lock coping; and between these, transversely, will be a breast wall of a height adapted to the assumed low water level of Lake Erie.

Above the breast a pier will divide the water-way into two equal spaces, in each of which there are to be two sluice-ways 4 x 4 feet.

The pier and side walls are to serve as bearings for a towing-path bridge and for purposes connected with the regulation of the water. Immediately south of the breast wall and opposite each division of the water-way, is to be a movable bulkhead, arranged in such a manner that there can be a constant flow of water over the top of it at any height the summit level may be kept.

The walls are to be built in the positions represented on the plan to be furnished, and for the most part are to be of the dimensions herein stated; they must throughout consist of an approved class of grey limestone, free from seams, drys, sand holes and other defects, laid in full mortar on their natural beds.

It should be clearly and distinctly understood by parties tendering, that it is only those parts of the work between the ranges of sheet piles at what is called the upper and lower ends of the weir which will be measured, estimated and paid for as weir masonry.

SIDE AND WING WALLS—to be 8½ feet thick at bottom, face to be "rock work" with a batter of one in twenty-four, the stones to be at least 2 feet long in line of wall, 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed and not more than 10 feet apart in every course; the whole to be dressed and laid so that the beds and end joints shall not exceed three-eighths (⅜) of an inch. The backs of the walls are to be carried up plumb to within five feet of the top; thence batter to the rear line of the coping, which is to be 3½ feet wide, except those parts occupied by the bridge, where an offset of one foot is to be made for the ends of the stringers, opposite which the coping is to be 2½ feet wide.

BREAST WALL—to be 10½ feet in width at bottom, 4½ feet at top and 15½ feet high, built of stones 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, and not more than 9 feet apart, all of them must be dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper sides of the wall to be carried up plumb from an offset of 12 inches on the sill course, and the faces of all the stones dressed fair and smooth to receive the frame work of the sluices and bulkheads; the lower side is to be "rock faced" work laid to a batter of about 5 inches to the foot rise.

There are, as above stated, to be four sluice-ways through this wall, each 4 feet wide and 4 feet high, the top, bottom and sides of which are to be dressed smooth. The sills

under them and lintels over them to be from 15 to 18 inches in height and 6 feet long, each dressed so as to lay to close and full joints and present a fair surface throughout the respective openings.

The piers between the sluice-ways, in each of the two divisions of the water-way, are to be two feet in width and must be made up of stones the full thickness, neatly dressed on both faces, and when laid, bonded over and with each other at least one foot.

The centre pier is to be 6 feet 1½ inches in thickness at the floor, carried up to such a batter on both sides that the top shall be four feet in width. The pier, coping excepted, may be made up of two widths of stone, provided there are double headers in each course not more than 8 feet apart. This pier is to extend three feet beyond the bottom line of the breast wall, if directed.

In the face of the side walls and on both sides of the division pier at about 6 inches above the upper side of the breast wall, checks are to be formed 12 inches wide and 6 inches deep at the top, increasing in depth according to the batter of the wall so that their backs shall be plumb. They are to extend from the coping down to 7 feet below the top line of the breast wall to admit of raising and lowering the movable bulkheads.

Near the upper end of the weir, checks 12 inches wide and 2 feet apart, 6 inches deep at the top, made plumb at the back for the full height of the walls, are to be formed in the face of the wings and on both sides of the division pier for the reception of stop-timbers. Below these checks, a cross wall 3 feet in width and the same height as the sill course of the sluices is to be built of block stone the full width. The stones are to be secured to each other by dowels and vertical bolts in such a manner as may be required.

The arrises of all the face stones on both the upper and lower sides of the breast wall, the division pier, the sills, lintels, piers and sides of the sluice-ways must all be kept good, and the whole dressed and laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

COPING.—The breast wall coping must be at least 16 inches high and 4½ feet wide on top, increasing in width downward to the batter of the wall. The lower bed and joints of each stone must be kept full throughout, and the top dressed fair, so as to have a declivity of one inch toward the up-stream side. It is to be in lengths of not less than three and a half feet, be connected with dowels at the joints, and secured with bolts to the course underneath.

The coping stones of the side walls and division piers must be at least 12 inches in thickness, have full beds and joints and be neatly boucharded on top.

In addition to the range of sheet piles to be placed in line of the breast wall, a counterfort of masonry, 4 feet thick and 6 feet in length, is to be carried up in connection with each of the side walls to within 4 feet of the top of the coping.

In the lower wings, offsets or steps are to be made in the different courses so as to give the top of the wall, from a point five feet below the line of the breast wall, an inclination of about two horizontal to one vertical.

BACKING—to be of an approved class of large-sized, well-shaped stones not less than six inches in thickness, laid on their broadest beds in full mortar and bonded over and with each other throughout the wall.

The whole of the weir masonry must be laid in the best hydraulic cement mortar, mixed and prepared as previously described for other parts of the masonry on the section.

A puddle bed 3 feet in width is to be carried up in rear of the side walls to the full height of the summit level.

The material used for this purpose, as well as for the puddle between the foundation timbers and for the sheet pile trenches, must be of the best and most suitable kind that can be found on the section or in the vicinity of the works.

SLUICE GATES—to be built of the best quality of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to 3½ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths (⅞) of an inch in diameter, passing through the gate; and to have straps of wrought iron 3 inches wide and three-eighths (⅜) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush, and fastened, at distances not more than 6 inches apart, with rivets ½ an inch in diameter countersunk into the straps. The top plates are to be 2¾ inches deep, and those at the bottom 6½ inches deep, each to have a flange from the centre outwards on opposite sides.

They are either to be made the full height of the opening in the breast wall, or the upper part of the opening is to be closed up, and the height of the gate diminished, as may be subsequently determined. In either case the gates are to revolve on the centre, or pivots working into the bottom plates of the gates, and on the top of each a disc of steel or hard brass is to be placed, and have a brass collar and lining. The pivots are to be 3½ inches diameter, connected with plates 9 inches square and 2 inches thick, let into the sills of the sluice-way, and secured to them by fox-bolts.

The gates are to arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key-bolts to the piers and lintels of the sluice-way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed.

The turning rods are to be of wrought iron of sufficient length to pass through the gates, and stand six inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates, and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected with racks on the platform, made so as to secure the gate in the position required.

The bulkheads are to be of pine timber 12 inches square, planed, jointed and secured to each other with bolts passing vertically through them having suitable tightening nuts and washers. As a means of raising or lowering them, a rod will be attached at both ends near the recesses in the walls, which will work through a brass matrix fitted into castings, secured to the timber work, and the upper ends of the rods are to have bevel spur-wheels keyed on to them, to gear into pinions on crank shafts attached to the bridge.

If considered desirable to work the two gates in each division of the weir at one time, it is to be done in a similar way to that above stated for the bulkheads. The prices tendered for the different items of iron work are to be understood as being applicable in either case.

BRIDGE—to be formed of stringers of pine timber 12 x 12 inches, placed 2¼ feet apart; they are to rest on the tops of the pier and in the offset made by the coping on the side walls, and are to be fastened to the masonry with fox-tailed screw-bolts one inch diameter. The outer stringers to be double, with distance pieces of oak 12 x 12 x 5 inches between them, placed about 5 feet apart and connected with screw-bolts one inch and a quarter diameter.

The covering to be of 3-inch plank of a length to reach across the bridge ; they are to be fastened with 7-inch pressed spikes.

From the lower end of the weir to the water-course on the west side of it, a tail-race is to be cut to a depth of about 6 feet below surface water line of the reach north of the lift lock, made 30 feet in width at bottom and with side slopes of about one and a half horizontal to one vertical, unless adjoining the weir, where a protection wall of dry rubble masonry is to be built on both sides for a distance of from 30 to 40 feet.

Opposite the site of the weir, or on the east side of it, a dam must be formed in a depth of about six or seven feet of water below the assumed level of Lake Erie, to enable the side walls to be extended to as great a distance above the weir as can be done with safety.

This extension of the walls is not, however, to be proceeded with until after the weir has been completed up to the line first mentioned, namely, the rear side of the present towing path ; nor until the sluice-gates and bulkhead are in place, and the whole in efficient working order.

When this has been satisfactorily accomplished, the space between the weir and the dam is to be deepened, and the side walls built to such an extent as can be done with safety.

To sustain the sides of the channel, for a distance of 16 feet or more at the immediate entrance, two ranges of piles of 12″ x 12″ timber are to be driven on each side in continuation of the side walls, the water-way is then to be made of the required depth by means of a dredging machine, and the tops of the piles cut off to about one foot below the side slope of the canal bank.

Parties when "tendering" should bear in mind that this weir must be constructed between the time that the contract is awarded and the opening of navigation in April 1878. To be certain of this, all the materials for the works must be provided and delivered, and part of them prepared by the 15th day of November next, and the contractor's arrangements must be such as to fully satisfy the Department of Public Works that this portion of the works will be completed at the time above stated. Clear and satisfactory evidence to that effect must be given before the present weir, opposite the foot of the lift lock, can be removed or the channel leading to it blocked up or in any way diminished.

Where the supply will enter the canal below the lift lock, the outlet is to be enlarged to a mean width of forty feet and be made with a direction downward to within 60 degrees of that of the centre line of the canal.

It is to be sunk to the depth of 8 feet below the surface water level of the adjoining reach. The abutments and centre pier are to be built of large-sized, well-shaped stones, laid throughout in cement mortar ; all the expenses connected with which are to be embraced in the respective rates tendered for the work. The bridge over the outlet to be made similar to the one to be formed over the upper end of the supply weir.

At a point about 400 feet above the guard lock an opening is to be formed through the east bank of the canal to allow the surface water that collects there to enter the canal. The sides of the opening are to be of rubble masonry laid in cement mortar, and the face of the bank below the bottom line of the opening is either to be of pitched stone, or a well is to be sunk to discharge the water into the canal, two feet or more below the assumed level of Lake Erie.

In short, the disposing of the drainage and surface water at this place is to be done in a similar way as described in a preceding part of this specification for other places, except that the openings will be of larger dimensions.

For the two small branches of the Beaver Dams Creek, situated about the middle of the section, two single arch culverts are to be constructed, each 4 feet in width—one, opposite what is called Higgins' Culvert, on the old canal, is to have bench walls one foot high; the other, opposite what is called Davis' Culvert, is to have bench walls two feet high. They are both to be of masonry, laid in hydraulic cement mortar, prepared as previously described, and placed on a foundation of timber and plank, laid at a depth that will admit of placing at least two feet of puddle over the crown of the arch, and still leave the top surface 15½ feet below the assumed low water level of Lake Erie.

The foundation timbers are to be of pine, 12 inches square, laid transversely from 4 to 6 inches apart, the spaces between which are to be filled with puddle or concrete as may be directed.

Floor to be of 3-inch pine plank, jointed with a plane and laid so as to break joints at every three feet in width, and be fastened with 7-inch pressed spikes, two in each end of a plank and one on alternate sides at every crossing of a timber.

A course of 3-inch sheet piles sunk 5 feet below the top of the timbers is to be placed at each end, for which trenches 2½ feet in width are to be dug and afterwards well filled with puddle. The heads of the sheet piles are to be secured to the foundation timbers with 7-inch pressed spikes, two in each plank.

The stones of the side walls or abutments must have at least 2 feet width of bed, with headers at intervals of every 8 feet; the arch stones are to have a width of 15 inches and be dressed to radiate truly for their full depth.

The beds and joints of all the face stones of the side walls, wings and arches must be dressed throughout so as to lay to joints not exceeding five-sixteenths of an inch. The faces of the stones must also be dressed fair and to lines corresponding to the position they are occupy; the wings and parapet walls are, however, to be "rock faced" work.

Coping to be 3 feet wide and 12 inches thick in lengths of at least 3 feet, the top of which must be neatly boucharded; the beds and ends are to be dressed so as to lay to mortar joints of one-fourth of an inch.

The abutment walls are to be 3 feet thick, carried up to one foot below the crown of the arch, in each case.

Between the abutments and banks, puddle walls for the entire width of the opening and length of the culvert are to be carried up to canal bottom, and over the arch a puddle bed two feet in depth is to be laid for the entire width of the canal and of that of the embankments on both sides.

For the purpose of enabling the work on the section to be proceeded with, the canal will be emptied as nearly as circumstances will permit, in the early part of December, 1877, and the water will be allowed to remain out until in April, 1878.

The contractor's arrangements for proceeding with the works must therefore be such that every possible advantage will be taken of the time above mentioned to urge them forward in an energetic and satisfactory manner.

Contractors are, however, distinctly informed that shutting off the water, as above mentioned, will not have the effect of laying the bottom of the canal dry, several feet of water will still remain in it.

This unavoidable state of matters should be borne in mind by contractors when "tendering," as well as the fact that the only possible way of getting rid of the water is by pumping, and moving part of it when frozen.

When preparing their "tenders," contractors should bear in mind that the respective bulk sums for unwatering the different parts of the works, at the different times stated, must in each case embrace the construction of all dams, their full maintenance and their removal at the time directed, also the providing and fitting up of all pumps and machinery that may be required for that purpose, together with the removal of all snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundation of all structures on or connected with the section, must all be included in the respective bulk sums stated in the tender.

During the progress of the works the different parts of the *earth* excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of excavated or dredged material, or in proceeding with any other part of the operations connected with the works, the contractor must be governed by the canal regulations, and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding, or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated, are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed drawings, arranged, modified and adapted to the circumstances and the locality, for all such parts of the structures as may be considered necessary for the full understanding of the design, will be furnished as the works proceed.

If any alterations be rendered necessary by any cause, or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials; furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the

satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the fulfilment of the contract satisfactory security will be required, by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the fullest advantage will be taken of the time when the water is out of the canal between December, 1877, and the opening of navigation in April, 1878, to urge forward to completion all such works as would in their execution be retarded, or in any way interfered with, when the water in the present canal is at its usual height. To be certain of this, all stone, timber and other materials required for the works of the supply weir and retaining wall at Allanburg must be provided and delivered this autumn, all such works done and such arrangements made as will fully satisfy the Department of Public Works that every effort has been made and continues to be made as will warrant the conclusion that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 1st day of June, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 7th August, 1877.

APPENDIX No. 13.

Thorold, 11th December, 1879.

SIR,

I have the honor to submit the following report on the state of the works in my charge on the 30th November, 1879 :

As stated previously, these embrace the deepening and enlargement of Port Dalhousie Harbor and the construction of twenty sections of the new Welland Canal, stretching from Lake Ontario to Allanburgh, a distance of 11·83 miles, on which the twenty-five locks necessary to attain the level of Lake Erie are situated.

This part of the canal is now so far advanced towards completion that all the work embraced in existing contracts can be easily finished next year. Sections Nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 13 have been finally estimated. Sections Nos. 14, 15, and 16, are completed, and on Sections Nos. 1, 12, 17, 18, 19 and 20, but little of importance remains to be done.

The names of the contractors and dates of contracts on the new line are as follows:—

No. of Section.	Names of Contractors.	Dates of Contracts.
1	Patrick Larkin	16th Oct., 1875
2	Denison, Belden & Co	6th April, 1874
3	do do	6th April, 1874
4	Blake Bros. & Campbell	27th July, 1875
5	Alexander Manning	31st Aug., 1874
6	Patrick Shannon	4th June, 1874
7	Higgins & Sullivan	3rd June, 1874
8 & 9	Cairns, Morse, Hart & Co	21st July, 1873
10	John Ginty & Co	18th July, 1873
11	Paul Ross	5th Aug., 1873
12	Messrs. Lobb, Dawson & Murray	27th July, 1875
13	Ginty & Dickey	29th June, 1874
14	John Brown	2nd April, 1874
15	John Brown	17th July, 1873
16	John Elliott & Co. (afterwards John Brown)	18th July, 1873
17&18	Robert J. Campbell	26th Sept., 1877
19&20	Haney, Haney & Parry	29th Sept., 1877

The approximate quantities of principal items of work done up to 30th November, 1879, are as follows :—

Earth excavation, cubic yards	5,375,000
Rock do do	150,000
Masonry, cubic yards	369,000
Timber, feet	1,475,000
Plank, feet B.M	4,000,000
Puddle, cubic yards	150,000
Concrete, do	37,000

Section No. 1.

The east entrance pier of Port Dalbousie Harbor has been extended 300 feet lakewards, and the west pier similarly lengthened.

The lines of crib work forming these are thirty feet wide, two hundred feet apart, and sunk on a bottom carefully dredged to receive them. The work has stood well considering its exposed position. The head of the east pier is made up of four cribs 30′ x 30′ placed so as to form a square, upon which a small lighthouse has been erected. This stands on a platform six feet over the level of the superstructure or about eleven feet over ordinary lake surface.

The new portions of the work are solidly filled with stone, and planked over on top.

The larger lighthouse, previously built, has been permitted to remain, forming, with the new and smaller one, range lights by which the entrance to the harbor is at all times easily and safely made.

The docking on each side of the addition to the harbor has been almost entirely completed, the aggregate length being about 1,640 feet. This is formed of crib work 18 feet wide, sunk one foot below bottom, well filled with stone and having a gravel finish on top of the superstructure, which, like that of the entrance piers, is carried to the height of about five feet over the general level of the water.

On the west side, a considerable space behind the docking has been filled in with earth, making valuable ground of what was previously shallow water. The harbor room has been doubled, there being now an inside area of about sixteen acres. This is irregular in shape, but at one point it is five hundred feet wide, so that large vessels can turn with ease.

The harbor, and between the entrance piers, has been dredged to specification depth; namely, 15½ feet at the tail of the new entrance lock, increasing to 16½ feet at the outer end of the piers. These soundings are referred to datum of low water of Lake Ontario; or when there is twelve feet on the mitre sill of the present Lock No. 1.

The prevalence of westerly winds has, however, driven the beach sand through the openings between the cribs forming the old work of the west pier to such an extent as to shoal the water inside considerably. Thus, although the bottom was taken out to the required depth in 1875, the drift alluded to had to be again removed in 1878; and now the depth, for a considerable distance alongside the inner face of the west pier, averages only from 8 to 10 feet. It is therefore evident that some measures must soon be carried out at this place to permanently secure the full depth required for the enlarged navigation.

In dredging for the seats of the docking cribs in the harbor, a small area of reddish shale, met with near the Welland R. R. Company's elevator, had to be removed, by blasting under water, to obtain the required depth.

The new entrance lock is located at a high point in the right bank of the Twelve Mile Creek. The foundation of this structure, from the breast wall to the north end of the pit, is on reddish sandstone rock, except for a small triangular-shaped space in the north-west angle, where the rock suddenly slopes off, until the borings shewed at one point about 30 feet in depth of soft muck. This space was boxed in by rows of close oak piling, and a stratum of concrete about five feet in depth placed under the mud sills, the clay having been removed for that purpose.

The side walls of the lock are 31 feet 2 inches in height, and the mitre sills are 3 feet lower than those of the present entrance lock. The ordinary lift will be from 12 to 13 feet.

Above the breast wall the foundation proved soft also, and as the upper wings had to be extended to carry a swing bridge over them for the main road between Port Dalhousie and St. Catharines, a bottom formed of piles and concrete was put in for the purpose. The walls built on this have stood well, and the whole of the masonry of the lock is now completed.

The lower wings are extended on each side by sloping walls of rubble, from 140 to 150 feet in length, resting on cribs sunk to receive them, and connecting with the docking on each side of the harbor.

The southern entrance is formed by two diverging lines of pier work, about 240 feet each in length, which will serve to guide vessels entering or leaving the inner basin.

A short distance west of the new lock there was a weir which served to regulate the long level above the entrance, which reaches up to lock No. 2 at St. Catharines. This structure had for many years shown symptoms of weakness owing to unequal settlement in the foundations. This resulted in a crack through the breast wall, and on the 13th September, 1878, during an exceptionally heavy freshet, the weir went out, and the immense body of water behind it rushed through the breach into the harbor. Immediately to the north of the new lock, on the west side, there are several openings left in the docking previously referred to, by which the tail water of the adjacent mills and that from the weir escaped. In the rush which followed the failure of the weir, some of these cribs were damaged, and a considerable amount of earth was swept into the harbor, which will again have to be dredged out in several places to specification depth.

In order to provide ample means for controlling the level of the long reach above Lock No. 1, a surface weir has been constructed in the dam, just south of the present entrance lock. This consists of a series of low overfalls, which divide the drop from the surface of the canal above, to that of the harbor, which, in ordinary circumstances, is about 13 feet. The upper breast wall is divided into four compartments of about 16 feet each, through which the water passes freely when it rises above navigation height. At the head of the weir the main road, which also crosses the new entrance lock, is carried over by a substantial bridge. From the west side rail of this, the slash boards for regulating the flow are operated.

Borings taken before the work was begun shewed soft material at a depth of over 25 feet, and great care was therefore necessary to secure a good foundation. This has been satisfactorily accomplished by enclosing the whole area of the site with 12" x 12" pine sheet piles from 25 to 30 feet in length, a row being also driven at each of the low cross walls forming the steps of the weir. The masonry of this structure is, throughout, first-class. It has been entirely completed and in operation since March of this year, and has already been found of essential service on several occasions.

A new and considerably enlarged regulating weir is also about being built to replace that carried away. The site chosen for this will, it is believed, afford a uniform foundation on hard material.

The contract for this structure having been recently let to Messrs. Usher & Battle, of Thorold, the work of excavation was begun last month.

The construction and removal of coffer dams at both ends of the entrance lock; the taking away of what was known as Andrew's Dry Dock, etc., etc., has been accomplished;

and beyond the trimming up of the earth slopes (which will be done next spring) the work embraced in the contract for Section No. 1 may be said to be completed.

The distance from the head of the east pier to the inner angle of the entrance is 2,320 feet; thence, across the harbor, to the foot of Lock No. 1 is 2,008 feet; in all 4,328 feet.

From the latter point, across the inner basin, to the lower wings of Lock No. 2, the distance is 2,070 feet. The west entrance piers to Locks 1 and 2 from the basin will be connected by a towing path about 1,100 feet in length; the construction of which has not, however, been yet begun.

Sections Nos. 2 and 3.

On these sections there are four locks, four regulating weirs, a masonry dam and several minor structures. The work also embraces the construction of two entrance piers at the lower end of Lock No. 2, and the removal of about 450,000 cubic yards of earth, etc., etc.

The mitre sills of Lock No. 2 have been arranged for a 14 feet navigation when the surface of the inner basin is at its usual height of 12 feet over datum. The lift of the lock will be 15 feet, the walls being 32 feet 1 inch in height. This lock is placed in a high point in the left bank of what was called May's Ravine, being a deep gully branching from the wide basin forming a part of the present canal.

On getting down to foundation level, the material composing the bottom of the pit was found to be so variable that 12 inches of concrete was placed under the cross timbers, the spaces between the latter, together with the sheet piles, being also solidly filled with concrete. Upon this the usual floor of 3-inch planking was laid, and the side walls carried up to full height.

The water will be set back in the canal above Lock No. 2 to a surface height of 27 feet over datum, and, although there is a considerable curvature in the reach between this and Lock No. 3, (a distance of 1,300 feet) yet the shape of the ravine permitted of the prism being made 165 feet wide at bottom, with less than the ordinary outlay for earthwork. This length, in fact, forms a basin generally 217 feet in width at water line, and having a surface area of about 6¾ acres, thus rendering navigation easy, and at the same time obviating the necessity of constructing any reservoir alongside the reach.

The east upper wing of the lock is connected with a regulating weir, built in the right bank of the ravine, by a stone dam, the central part of which is 184 feet long and 36 feet 9 inches in height. The coping of this is on the same level as that of the lock, the extra depth being required to obtain a proper foundation in the bed of the old creek, where there were from 10 to 12 feet of soft muck overlying a stratum of gravel. Upon the latter platform of concrete, timber and plank was placed, and the wall built on it. The weir referred to is of the usual dimensions, and the whole of the work, notwithstanding the connection of several walls of considerable and unequal heights, stands as when built. The lower entrance to Lock No. 2 is formed of two diverging lines of pier-work, which project into the basin, respectively, 390 feet and 414 feet, the east side being the longer. The distance between the heads of the piers is 200 feet across.

It was at first intended that these should be formed of two rows of crib work, 16 feet wide, sunk as represented on the plan, and filled with either clay or stone ballast. Behind these, embankments, 25 feet wide on top, were to have been formed, the rear

slopes being protected at water line by rip-rap. When the work was begun, however, the bottom proved to be so soft and irregular, that the cribs, instead of being placed end to end, were sunk transversely, forming lines 30 feet wide on each side. These, in many cases, settled to a depth of from 10 to 12 feet below bottom line of canal; and were, generally, so much out of range that great trouble was experienced in getting the superstructure into tolerably fair shape. This, however, has been accomplished, and the tops of the piers are on a level of about five feet over the surface of the inner basin. The cribs are filled with clay below water line, but the superstructure is well packed with stone, having a gravel finish on top.

Close up to the lock, on the west side, the cribs, for a distance of 94 feet, were on sufficiently solid bottom to permit of an extension of the wing being constructed on them. This is of coursed masonry, the coping of which slopes downwards and outwards to the general level of the top of the superstructure of the piers. On the east side, however, the foundation was so soft that a similar slope of approach could only with safety be obtained by building up the timber work to the shape of the extension wall opposite. This has been done, and the work has stood very well.

A wide bank was formed on the east side of the lock, which will give ample room for all purposes connected with the navigation; and at the east end of the masonry dam, at the head of No. 2, a trestle bridge will be constructed over the opening to the regulating weir, so as to make the towing path continuous on both sides of the canal.

On excavating the pit for Lock No. 3, although the material met with was generally very hard, it was found that, at the required depth, a large area of the south end of the site was composed of a deep bed of quicksand. To overcome this unexpected difficulty, a system of cross trenching was adopted, leading into a main channel on the west side of the pit, connecting with a well in which a pump was placed, for the purpose of keeping the hitherto saturated quicksand surface as dry as possible. In this way, a crust was formed, and on top of it a layer of concrete two feet in depth was placed to receive the foundation timbers. Considerable trouble was experienced in sinking the sheet pile trenches, and getting them well filled with concrete. This was at length done, and the walls carried up to full height.

South of the breast wall, the upper wings of the lock had to be extended to form the abutments for a swing bridge over them. The material of the bottom at this place was also very soft, but by placing masses of concrete on each side, at the junction with the side walls of the lock (which are about 12 feet higher than those of the wings) settlement was avoided, and the whole of the work now stands without showing the least crack or opening in any part of it. This lock is 14 feet lift, the level above it being 41 feet over datum.

An extension wall of rubble masonry, part of which, next the lock, rests on a fender crib, has been built at the lower east wing. On the west side the extension is connected with a towing path bridge having three openings, 17·5 feet each, through which the water of the raceway, which leaves the canal above Lock No. 5, is returned into the reach or basin between Locks Nos. 2 and 3.

The channel is about 3,000 feet long, 60 feet wide at bottom, and on it there are three regulating weirs corresponding to the lifts at Locks Nos. 3, 4 and 5. In the reaches above No. 3 it communicates freely with the canal by towing path bridges on the west bank having two openings of 25 feet wide each. The raceway is thus used for passing the surplus water, whilst the considerable area of water surface enables it also to serve the purposes of side reservoirs.

Over this raceway, and nearly in line with the bridge at the upper wings of lock No. 3, the same highway from Port Dalhousie to St. Catharines is carried by a structure with a centre pier and two openings each 25 feet wide. This is built of well-faced masonry; and the road is continued westward by an easy curve in cutting to a junction with the present line.

The masonry of Locks Nos. 4 and 5 presents no special features for remark. The lifts at each are 14 feet, the levels being respectively 55 and 69 feet above datum. The reaches are 810 and 765 feet in length.

Between 3 and 4 the canal curves somewhat to the west; and, midway, the reach is made 150 feet wide at bottom. From Lock No. 4 south for over 4 miles the line is straight.

From lock No. 3 to lock No. 5 the prism is almost entirely in cutting, and a large amount of earth was thrown to spoil. This was necessary to get up to the level of the first plateau, which, at the end of section No. 3, is 60 feet over datum of mean surface of Lake Ontario.

As the natural drainage of the country between Lock No. 4 and the Queenston Road crossing at St. Catharines flows towards the north, this is intercepted by the canal and its works. It therefore became necessary to provide a large back ditch on the west side, by means of which the surface water is conducted to a branch of May's Ravine, connecting with the reach between Locks Nos. 2 and 3. At the point of outlet the bank is steep, and a masonry culvert has been built consisting of several steps, connected with an arch under the main road, a little to the west of the new route described near Lock No. 3. In this way the drainage, which is often very considerable, is satisfactorily disposed of; the arrangement having fully answered the intended purpose.

The earth excavation of both these sections was for the most part very hard. To remove this a powerful steam shovel was employed, which effected the desired object both expeditiously and economically. A large proportion of the 48,000 cubic yards of masonry embraced in these sections was rapidly laid up by the use of steam cranes; and, in short, it is but just to say that the general arrangements made for carrying out their obligations shewed clearly that the contractors were men of energy and experience; whilst all orders given to them by those in immediate charge of the works were both cheerfully and promptly obeyed.

Section No. 4.

The line between this section and No. 3, is 6,980 feet (1·32 miles) from the lower end of the entrance lock at Port Dalhousie. The section is 3,150 feet in length.

The work consists of the formation of the canal for the above distance, the construction of one railway bridge, one road bridge, and the formation of a new line for the Welland Railway of 5,944 feet in length.

The road bridge is a single track structure, built on the plan generally adopted. Between the pivot and bridge seat piers, which are placed at right angles to the centre line of the canal, the openings are 47 feet. On each side of the bridge seat piers there are two smaller openings with fixed spans. The abutments on both sides start from a solid foundation, and the slopes of the canal above and below them are faced for a certain distance with a lining of masonry, partly in cement and partly dry, to prevent wash where the prism is of somewhat less area than usual.

In the axis of the canal at a suitable distance above and below the pivot pier, there are masonry rests to receive the bridge when swung. These are protected both up and

down stream by tapering fender cribs solidly filled with stone, at the extreme ends of which clusters of protection piles have been driven. The spaces between the pivot and rest piers are filled with crib work. All three piers in line of the canal have arched culverts passing through them, and the crib work between has also several sub-aqueous openings for the purpose of permitting the water to flow freely from one side of the canal to the other during the passage of vessels.

To guide these safely through the channels a line of fender piles runs from the bridge seat piers into the canal banks at a suitable distance above and below the masonry of the abutments on each side. These piles are strongly fastened by waling pieces of oak, well bolted together, and are stiffened by struts reaching from the line of the face back into the solid earth. In some cases these struts are supported by a second row of piles, driven midway of their length to keep them from sagging. The whole arrangement is intended to prevent the possibility of interruption to vessels at the bridges, and to guard against damage to the permanent work.

The swinging part of the bridge will be 120 feet in length.

This road bridge will carry the extension of Lake Avenue in St. Catharines across the new canal, to accomplish which it had to be diverted for a short distance on each side. The curves and grades of approach are, however, easy.

Where the canal intersects the present Welland Railway on Section No. 4 the rails were nearly even with the ground surface, whilst the canal is in about 10 feet embankment, consequently the line had to be shifted and the grades re-distributed so as to secure the best crossing without interfering with the future navigation. To effect this it became necessary to form a new track, 5,944 feet in length, between the points of diversion. This leaves the present line a short distance south of the head of the grade from Port Dalhousie and rejoins at the north end of the curve leading out from St. Catharines station. This diversion is principally in embankment, and its levels are so arranged that the carrying capacity of the railway will not be lessened or its operations interfered with more than is unavoidably necessary. The bridge crosses the canal at an angle of about 52 degrees. The masonry of the structure is completed, together with its cribs, fenders, piles, etc., all of which are on a plan similar to that described for the road bridge. The work of this section cannot be entirely completed, however, until the line of the railway is changed so as to pass over the permanent bridge. Under the circumstances, it was considered best to take the section off the contractor's hands, and it has, therefore, been finally estimated.

In addition to the bridges, there have been two culverts constructed over the back ditch—one for the purpose of carrying the new railway, and a smaller one to serve for the crossing of Lake Avenue.

The canal on Section No. 4 is of the usual dimensions; but the earth-work quantities exceeded what were anticipated, on account of a large amount of sand or material unfit for making water-tight embankments having been found in the prism or along the sides, in many places.

Section No. 5.

This section is 3,200 feet long, and on it two locks, (Nos. 6 and 7), two regulating weirs, two towing-path bridges, one railway bridge and a small culvert have been built.

The foundation of Locks Nos. 6 and 7 being of soft clay, a foot of concrete was placed under the foundation timbers. The upper wings of No. 6 were extended to carry a swing bridge for the crossing of Geneva street, St. Catharines. Both locks have the

usual retaining walls of rubble masonry at their upper and lower ends, and the latter are partly built on fender cribs 13 feet high and 36 feet long, adjoining the wings and conforming in front to the twisting batter of the stone work, which changes from the almost vertical face of the lock masonry to the usual slopes of the earthwork, in a distance of 100 feet. These cribs are carefully filled.

At the dividing line between Sections Nos. 5 and 6 the surplus water will pass out of the canal, on the east side, through the openings of a towing path bridge, into a small reservoir of about 1½ acres area. In the north bank of this a regulating weir has been built, the openings through which communicate with another reservoir of over 4 acres area. This is alongside of, and connected with, the reach between Locks Nos. 6 and 7 (which is 1,500 feet in length), and discharges by a second weir into a raceway which is continued northward and terminates in the canal a short distance below Lock No. 6. The reach below the latter is 4,400 feet long.

Over this raceway, and in line with the crossing on Lock 6, a bridge with two openings has been constructed to carry Geneva Street. The superstructure of this is completed, together with all the work embraced in the contract for Section No 5.

The amount of earthwork was increased, from a similar cause to that mentioned in connection with Section No. 4; and the same remark will apply to Section No. 6.

3,676 cubic yards of concrete were used in the foundations of the structures on this section.

SECTION No. 6.

This section is 7,000 feet long, and the work consisted principally of earth excavation, of which over 330,000 cubic yards were taken out. A double track road bridge in line of Niagara Street, St. Catharines, has been built, together with its slope walls, cribs, fenders, etc., etc. This street is also carried over the ditch in rear of the canal by a small bridge; the approaches on both sides to these structures being wide and the grades very slight. No pains have been spared to render this crossing unobjectionable from any reasonable point of view.

There being several roads converging to this point, the travel will probably be considerable, but the bridges can doubtless afford ample means of passing it without any inconvenience to the public.

Just south of the bridge one of the city water mains is carried under the canal at a safe depth, and every precaution has been taken to prevent accident at that point when the new canal is filled and the level of its surface is raised about 10 feet over the adjoining country. The embankment seats, on both sides, being in many places partly on sand, puddle walls were carried up in the centre, starting from trenches dug into the solid clay underneath. Nearly 15,000 cubic yards of this material were used on Section No 6.

Two towing path bridges were built, one at the north and the other at the south end of the work.

The whole has been taken off the contractor's hands and finally estimated. This section lies between Locks Nos. 7 and 8, which are 7,400 feet apart.

SECTION No. 7.

This is 3,083 feet long, and on it there are two locks, each 12 feet lift, built on the usual plan. The bottoms of both were concreted, the clay underlying the foundations being soft. Under Lock No. 8, the concrete is 12 inches thick, and under Lock No. 9, there are 15 inches.

The length of reach between these structures is only about 700 feet.

Just south of Lock No. 9, there is a towing path bridge in the east bank of the canal, which passes the surplus water into a reservoir 4.21 acres in extent. From thence it flows through a regulating weir discharging into another basin, alongside the short reach between Nos. 8 and 9, and having a surface area of 7.43 acres.

In the north bank of this there is a second weir discharging into a third reservoir of small extent, the short raceway, leading from which returns the water to the canal through the towing path bridge described as having been built at the south end of Section No. 6.

A double track swing bridge has been constructed at the Queenston Road crossing, near the St. Catharines Cemetery, together with all the usual slope walls, cribs, fenders, etc. The previous line of the highway has been changed so as to afford an easy approach to the new structure, the masonry of which is first class. A temporary bridge is at present in use at this point awaiting the erection of the permanent superstructure.

The centre of this bridge is 22,836 feet (4.32 miles) from the entrance lock at Port Dalhousie.

The section has been finally estimated.

Sections Nos. 8 and 9.

On these sections there are three locks, each 12 feet lift, built in accordance with the general plan. The distance between Locks Nos. 9 and 10 is 2,250 feet.

A short distance south of Lock No. 10, on the west side, there is a tow path bridge opening into a small reservoir of about 2½ acres in extent. From this the water passes the lock through a regulating weir, built in its north bank, and communicating with a raceway 60 feet in bottom width, 900 feet long, which leads into the main canal below.

At the crossing of the road from Thorold to Homer, a single-track bridge of the usual dimensions has been built to accommodate the travel. This has been completed for some time.

A little to the north of this, the Ten Mile Creek is passed under the canal by a double 8 foot arched culvert, 278 feet in length, which is found to afford ample discharge for the water of the stream during the heavy freshets to which it is liable.

All the locks from No. 4 to No. 11 are on the same straight line. In the reach between Nos. 11 and 12 (689 feet) the line deflects to the west about twenty degrees, and is then continued in a direct course for 4,500 feet. On this length Locks Nos. 12 to 16 are situated.

At No. 11, the rapid ascent of the "mountain" is begun, and from this point south to No. 24 the locks are placed as close together as practicable. There is, however, in all cases a sufficient distance between them to permit of the largest vessels which can navigate the new canal passing each other with ease.

The surplus water which is conducted out of the canal near the head of Lock No. 22, flows through a series of extensive side ponds formed on the west or north-west side of the main channel, and only re-enters the latter a short distance below No. 11. In each of the banks separating these basins there is a regulating weir; and in the left bank of the canal there is a towing path opening, in every reach, which permits of free communication between the reservoirs and the canal.

The works of Sections Nos. 8 and 9 were satisfactorily completed and finally estimated.

Section No. 10.

Lock No. 13, which has 12 feet lift, carries the line between the 9th and 10th concessions of Grantham Township across its lower wings, which have been extended for that purpose. On the east side the approach to this is 380 feet long, the grade being 1 in 25. On the west side the road is carried on a heavy embankment, which divides the upper from the lower portion of the reservoir alongside the reach between Locks Nos. 12 and 13. To the west of this basin, which has an aggregate area of 9 acres, the new road descends to the level of the old highway, crossing a small tributary of the Ten Mile Creek by a culvert about 750 feet from the centre of the bridge over Lock No. 13.

In the lower bank of the reservoir there is, as usual, a regulating weir communicating with that to the north. The latter has an area of over 6½ acres, and serves the reach between 11 and 12. The pond discharging into the level north of 11 is about 4½ acres in extent.

In the foundations of Lock No. 13, the spaces between the timbers and the sheet pile trenches were filled with concrete; but at Lock No. 4, the bottom was of soft clay, and 15 inches in depth of concrete was placed under the cross timbers.

Lock No. 14 has a lift of 12 feet, and is built on the general plan.

Beside the two locks, two weirs and two towing path bridges of this section, there has been constructed a bridge with two openings in the dividing embankment previously referred to, over which the concession road is carried. The permanent superstructure has been placed on this.

The work on Section No. 10 has been completed and finally estimated.

Section No. 11.

On this section there are two locks: Nos. 15 and 16, each 14 feet lift, built on the general plan.

The side basin for the reach 15—16 is 7·6 acres in extent. The surplus water passes through a regulating weir into the adjacent pond, which serves 14—15 and has an area of 8.6 acres.

At the south end of this section the canal is in heavy embankment, and advantage was taken of this, together with the facilities for drainage into an adjacent creek, to construct a masonry tunnel under the canal to pass the road from Thorold to St. Davids. This structure is 330 feet long, 14 feet wide, and 14 feet from the top of the paving to the soffit of the arch. The approaches to it from each side are wide and on a gentle grade, and the arrangements generally in connection with the crossing have been found to answer fully the purposes intended.

The road is continued westward from the tunnel, and at a distance of 600 feet from the latter it is carried across the raceway which leads out of the basin, serving the reach between Nos. 16 and 17 into that alongside of 15—16. The bridge at this place is a substantial structure, and the grades easy.

Just south of this, and close to the railway bank, a regulating weir has been built across the raceway, the water above which will stand at a level of 209 feet over datum.

The works connected with Section No. 11 have been satisfactorily completed, and finally estimated.

SECTION No. 12.

This section embraces a large amount of work in connection with the canal and the new line for the Great Western Railway.

There are two locks (Nos. 17 and 18) each 14 feet lift, two regulating weirs, and two towing path bridges, etc.

The bottom of No. 17 was found to be soft clay, and 2 feet in depth of concrete was placed under the side walls, 1 foot being laid under the cross timbers in the central part. With this exception, the lock was built, as far as completed, on the usual plan.

Lock No. 18 is of the ordinary dimensions. The length of reach between 17—18 is 754 feet.

The reservoir which serves the reach between 16—17 has an area of 8·5 acres; that for 17—18 is 77 acres in extent.

Between Locks 17 and 18 the canal again bends to the west, and the central part of the reach is 130 feet wide at bottom.

The section is 2,115 feet in length.

The works connected with the railway diversion are now completed as far as possible until the track is changed.

The canal line intersects that of the Great Western Railway at 34,218 feet (6·48 miles) from the entrance lock at Port Dalhousie, and where there is a long curve of 5,730 feet radius on a grade of 38·54 feet per mile. The road is also in heavy embankment at this place, and generally the objections to crossing by means of a bridge over the lower wings of Lock No. 17 as originally contemplated were considered to be so serious that the company's proposal to pass the railway under the canal was assented to as represented on a plan submitted by their Chief Engineer.

Both the linear arrangement and grades shewn upon this have been strictly adhered to throughout.

The new line leaves the present track 2,310 feet to the east of the intersection above referred to. At this point a curve of 2,865 feet radius begins, bearing to the south-west for a distance of 1,682 feet, and with the grade shewn of 42 feet to the mile. There is then a tangent 1,072 feet long, on the same incline; and from the south end of this, a curve 1,443 feet radius sweeps round to the west, on which the tunnel is situated. The curve is 2,512 feet in length and from its west end the line is straight for 445 feet. It then joins the present track by a curve 1,770 feet in length, the radius of which is 2,865 feet, the grade of the new line westward of the tunnel being 21 feet to the mile. Thus the total length of the diversion is 7,481 feet, whilst the distance between the same points, measured along the present track, is 6,175 feet.

The new railway is generally in heavy cutting; the depth at the central part being about 35 feet. Towards the Ten Mile Creek this runs out, and at the crossing of the valley there is a high embankment which had to be widened considerably, involving an addition to the arched culvert of 50 feet.

The road bed is made 24 feet wide at formation, with side slopes of 1½ to 1, carefully sodded and thoroughly drained. The toe on both sides of the track is supported by low retaining walls, connected with pitched drains, of suitable dimensions to carry off the surface water; the whole being laid in hydraulic cement mortar. The tunnel, which runs under the canal and side reservoir, near Lock No. 18, has 665 feet in length of arch, which with the wings gives a total length of 713 feet. It is 16 feet wide at rail surface, and the soffit of the arch in the centre is 18 feet over that level.

Channels of pitched stone and concrete have been formed throughout on both sides, prepared also with a view to receive the longitudinal timbers on which the track will be carried.

The masonry of the tunnel is throughout first-class, as called for by your specification.

Near the east end of the new line the railway crosses a small stream, and at this point an arched culvert of six feet span has been built. This also receives the water of the back ditch, which runs along the foot of the mountain on the east side of the canal. The quantity passing through this during heavy rains is very considerable, and some provision should soon be made to convey the whole discharge at the culvert under the present railway where there are no adequate means of doing so at present.

At the eastern point of diversion the level of the new rail will be 7·85 feet lower than that of the existing track. If the grade of 42 feet per mile, shewn on the plan referred to, is continued eastwards, to an intersection with present grades, it will involve the lowering of the main line for a distance of 4,366 feet. Part of the excavation necessary to accomplish this will be in rock.

Until this is done, the works embraced in the contract for Section No. 12 cannot be fully completed.

The dressing of the earth slopes of the canal, reservoir, banks, etc., has been postponed till next season.

The excavation for the railway diversion was generally stiff clay, a large portion of which was thrown to spoil at the last end of the new line. As, however, the whole of the material was specified to be taken into the valley of the Ten Mile Creek, only the measurement of the cutting is estimated, no borrowing from pits being paid for.

Where the road from Thorold to St. Davids crosses the new line a substantial overbridge has been built.

On this section there are over 42,000 cubic yards of masonry.

The work has been carried on in a satisfactory manner.

SECTION No. 13.

On this, there are two 14-feet lift locks (No. 19 and 20) two regulating weirs and two towing-path bridges. Two side ponds have been formed in connection with the reaches between Locks Nos. 18 and 19 and 19 and 20. The former has an area of about 5, and the latter 5.1 acres.

The works are completed and finally estimated.

The length of the section is 2,000 feet.

Sections Nos. 14, 15 and 16.

The extensive works embraced in these sections, although let separately, were all carried on by the late John Brown up to the time of his death in June, 1876. Since that period the general superintendence of the completion of the contracts devolved upon Mr. R. B. McPherson, who has performed the duty in quite a satisfactory manner.

The aggregate length of Nos. 14, 15 and 16 is 7,575 feet, and in this distance the greatest obstacles encountered in the location and construction of the new part of the canal have, it is believed, been successfully dealt with.

In endeavoring to establish a profile of nearly uniform ascent along the face of the mountain, in such a position that a chain of single locks could be built at the required distance apart, the ravine behind Thorold offered obvious advantages for attaining the summit level.

The difficulties, decreased by this natural excavation, were, however, by no means removed, and a very careful investigation of the vicinity had to be made to secure the most favorable site for the new work. On Sections 14 and 15 there are four locks. No. 21 has 14 feet lift, and is built on the general plan. It was the first completed on the canal, the walls being coped in May, 1876.

On excavating the pit for Lock No. 22, the south end, as located, reached into the shale underlying the limestones forming the edge of the escarpment. Part of the bottom being in clay and part in soft rock, the latter was removed for a depth of 6 inches and the former 15 inches below the underside of foundation timbers. These spaces were then levelled up with concrete; the sheet pile trenches and part of the rear of the side and breast walls next the rock, being also filled with that material.

The distance between Locks Nos. 21 and 22 is 640 feet; and on both sides of the canal there are reservoirs communicating with the reach through towing-path bridges of the usual dimensions. The area of the pond on the west side is 2·75 acres, and that on the east side, 2¼ acres. Into the latter, a portion of the surplus water from above will be discharged, by a raceway 30 feet wide, which is partly cut through the rock, in rear of Lock No. 22.

Across this there are two breast walls, dividing the fall from the surface of the reach above No. 22 to that below, the upper breast being provided with stop-logs to regulate the flow. This arrangement will tend to avoid the difficulty which might otherwise be experienced from cross currents in the canal at this important point.

From Lock No. 22 to the south end of the rock cut on section No. 16, a distance of 5,606 feet, the sides of the channel are formed either of masonry walls or of rock, the bottom width being generally 110 feet. In the reach between 22 and 23, however, the line curves 42½ degrees to the south on entering the Thorold ravine; and here, midway, the width is increased to 150 feet, the length being 715 feet.

In passing through the ravine, the Welland Railway had to be shifted 120 feet to the west, in order that the canal might occupy the central or deepest part of the valley. A new road bed was, therefore, formed for the line, involving, in some places, from 30 to 40 feet of cutting, a part of the lower portion of which was in rock, consisting of layers of limestone cement and shale, forming part of the upper strata of the Niagara formation. The level of the front edge of this, where first met with, is 302 feet above datum; whilst the height of the clay sides of the ravine is here about 340 feet over the same plane. As the stream has doubtless worn its way to the rock at the north end of the gully, these figures will serve to show the depth of erosion.

Between Locks 22 and 23, the prism was partly cut through a stratum of limestone, about 5 feet in thickness, which yields what is widely known as "Thorold Hydraulic Cement." This, when properly manufactured, is of excellent quality, and was almost exclusively used in building such of the walls as were designed to be water-tight, as well as in the preparation of concrete for the foundations of the locks and other structures.

For the whole distance from the head of Lock No. 22 to the lower wings of No. 24, the west side of the canal is lined with heavy retaining walls of rubble masonry, laid in cement mortar, and varying from 18 to 32 feet in height. On the opposite side, the walls are of dry rubble, and divide the channel from the raceway to the east of it.

This raceway leaves the canal, just above the head of Lock No. 24, by a short curve and towing path bridge with three openings each 19 feet wide. Its centre line is parallel to that of the canal, and 100 feet east of the latter. This is continued northwards, until it discharges over the breast walls and through the rock cut previously described, into the reservoir on the east side of the reach between Locks Nos. 21 and 22.

The raceway is separated from the canal for the greater part of its length either by the locks or a heavy rubble wall connecting them, 10 feet wide on top, so that a continuous towing path can be formed on that side, if required. Through this there are six openings, 19 feet wide, in each of the two reaches (22—23 and 23—24) through which the water can pass into or out of the canal. Thus, although there is no side pond attached to the reach 23—24, it is evident that the additional surface area afforded by the raceway alongside will serve a similar purpose and assist materially in the efficient working of the canal.

Two regulating weirs have been built across the raceway; one at Lock No. 24 and another opposite Lock No. 23. From the point where the side channel leaves the canal to the upper weir, its east side is lined by a heavy retaining wall of dry masonry. That opposite is stopped at the abutment of a bridge which will carry what is known as Hoover's Road over the raceway. Thence to the upper weir the slope of the bank in rear of Lock No. 24 forms the west side, and is protected from top to bottom by a covering of pitched stone laid dry.

Northward of this weir there is the heavy dividing wall previously mentioned, and on the east side of the raceway the foot of the slope of the deep cutting is supported by a rip-rap wall, the front stones of which are laid by hand. This extends the whole distance between the weirs at 24-23, the bank in rear of the latter lock being covered with pitching, as described for No. 24.

As before stated, from the entrance to the ravine the strata dip towards the south, so that at the north the foundations are generally in rock, whilst towards Lock No. 24 this disappears in many places, and the structures are built on clay.

Thus on excavating the pit for Lock No. 23 the lower end was in rock, which, however, fell away so that the upper portion, for a considerable area, had to be covered with concrete to an average depth of about two feet, to bring it up to the proper level to receive the foundation timbers. A large amount of concrete was also used in rear of walls when in rock excavation.

To the north of this Lock (No. 23) the bottom of the reach was found to be much fissured, and had, for a large extent, to be covered with a layer of concrete so as to prevent the escape of water. Just here the old falls of the Ten Mile Creek were situated, the stream being discharged over some ledges of rock. The gully was filled up with refuse from the adjoining quarries, and some difficulty was met with in obtaining a solid

foundation for the west retaining wall below the lock, which was partly built on concrete and timbers. It may here be stated that the reach between Locks Nos. 22 and 23 has on its west side a small reservoir of 2·2 acres in extent, with which it communicates through a towing-path bridge a short distance north of the head of Lock No. 22. This basin is at the top of the series which reaches continuously down to Lock No. 11, as previously mentioned.

The side walls of Locks Nos. 21 and 22 are each 29 feet 1 inch in height, but those of Lock No. 24 are 31 feet high, this structure being adapted to a 14 foot navigation in the reach between this and No. 25, a distance of 5,812 feet.

The surface of the rock met with in the foundations of this lock (Nc. 24) was so irregular that, in some parts, fully three feet in depth of concrete had to be placed under the cross timbers, the average thickness of that material being about 18 inches.

The upper wings are extended to receive the swing bridge for Hoover's Road, which will be carried over the raceway to the east as previously stated; and, in the same straight line (which is at right angles to the canal centre), crosses by a bridge of three spans the Welland Railway, which runs on the west side.

The reach between Locks Nos. 23 and 24 being also of fissured rock, it was covered throughout with a layer of good puddle 18 inches in depth. It is now perfectly water-tight.

The rear of the cement walls and of the lock walls on the west side of the canal is backed up throughout the whole length of the ravine by an embankment, the rear slope of which is 1½ to 1. This has been carefully sodded. Between the foot of the slope and the Welland Railway track, a channel to carry off the waters of the Ten Mile Creek has been constructed; 608 feet south of Lock No. 24 this stream is passed under the canal by a syphon culvert with two arched openings 6 feet span. The floor of this is 8½ feet below canal bottom—the well at the lower side being 6 feet in depth. The water rises over the lower breast, during heavy freshets, to a height of over 3½ feet. The general width of the conduit is about 10 feet, and its depth 4½ feet. The side walls are of masonry, and where on clay, the bottom is formed of an invert of heavy pitching one foot in depth, well bedded in 6 inches of gravel, and having cut-offs of stone set on edge. Towards the north end the bottom is of solid rock, which was taken out with much trouble and expense. This channel, from the culvert to its northern termination, is 2,300 feet in length, and is carried, by a culvert, under the railway, when the water is returned to the old bed of the stream.

The conduit has the same grade as the track, namely, 83 feet per mile, and its west wall forms one side of the new line.

This is 22 feet wide at sub-grade, and an excellent road bed was formed to receive the permanent way, which was taken from its previous position and relaid by the company under agreement with the Department.

It is stated that since the various improvements made in the line of this railway, during the progress of the canal works, heavier loads than formerly can be carried up the steep grade in rear of Thorold.

At the widest part the distance between the tops of the slopes on each side of the ravine is 360 feet. These slopes are all carefully sodded and thoroughly drained.

From Lock No. 24 southwards for a distance of about 1,350 feet, the excavation is in clay, part cutting and part embankment. Its sides are here lined throughout with heavy retaining walls of dry masonry, and, as before stated, the bottom width is 110 feet.

A series of layers of limestone rock is then again encountered, presenting a steep face; the top edges of which is a little over towing path level, or 325.5 feet above datum, at the highest point. This, however, slopes quickly to the south, so that at about 1,400 feet from where it is first met with the rock surface line intersects that of the bottom of the canal.

Where the former falls below the level of 325 feet, the difference is made up by the construction of retaining walls on each side. These increase in height and width until at the upper end of the rock cut they are of the full dimensions. At this point the hitherto slightly battered face of the masonry is twisted to the usual slope of 2 to 1, and terminates in a line of pitching.

From this to the end of the section the canal curves considerably to the west, and its bottom width is made 175 feet.

The work of these three sections is completed, and the final estimate for No. 14 is in course of preparation.

The stone road from Thorold to Clifton will be cut off by the works on Section No. 16, and a new route in lieu of this has therefore been constructed. It branches off from the old track about 660 feet east of the canal, and runs north along the boundary of the Government property to the line of Hoover's Road, when it turns to the west and runs alongside of (but separated from) the latter to the bridges crossing the upper end of Lock No. 24.

The new line has easy grades; the road bed is 30 feet wide, the central part being macadamized to a depth of 9 inches, for a breadth of 16 feet. Its total length is 1,742 feet, and it is carried over the Ten Mile Creek by a substantial double-track bridge, resting on abutments of a good class of masonry.

A new road has also been made along the top of the slope, on the east side of the canal, from the bridges at Lock No. 24 to the rear of Hoover's farm, where it turns east and is continued until it joins the north and south road leading to the Thorold Cemetery; a portion of the latter being improved up to the entrance gate. The new road is constructed on land purchased for the purpose, and is well fenced. Its total length is 3,200 feet, and it will doubtless fully answer the purposes intended.

The approximate quantities of the principal items of work on Nos. 14, 15 and 16, are as follows :—

Earth, cubic yards	795,016
Timber, feet	88,384
Plank, feet, B.M.	577,145
Puddle, cubic yards	22,958
Concrete, "	8,456
Masonry, "	79,279
Rock, "	146,424

It having been determined to continue the new canal by an independent route to Allanburgh, tenders were received for that purpose, and the contracts for Sections Nos. 17, 18, 19 and 20 signed in September, 1877, as previously stated.

SECTIONS NOS. 17 AND 18.

The length of canal embraced in the work of these sections is 7,581 feet. On this there is one lift lock (No. 25), one guard lock, a regulating weir, one railway bridge, one road bridge, two arched culverts, retaining walls, etc.

The masonry of the piers, abutments, etc., of the bridge to carry the Welland Railway over the canal at Marlatt's or Shriner's Pond, is completed and ready for the superstructure. Rock having been found at 2½ feet below canal bottom, this structure is founded entirely on it, the timber platforms having been dispensed with. The crib work, fenders, etc., are still in progress.

100 feet to the west of the centre line of this bridge, the railway is temporarily carried over a diversion consisting partly of embankments and partly of a strong trestle work, about 600 feet in length, which will be used until the track shall have resumed its original line over the new structure.

A short distance north of Lock No. 25, a single arched syphon culvert, 10 feet wide in the opening, has been built to pass the waters of Shriner's Creek under the new canal. The surface of the pond, through which the enlarged line is independently carried, is about four feet lower than the level above Lock No. 24, or 319 feet above datum. The soffit of the arch of the culvert is 303 feet over the same plane, so that the pressure on its surface is that due to a head of 16 feet. The culvert has been arranged to meet the maximum pressure, which occurs when the new canal is empty and the pond outside at its highest level during freshets. Timbers have been laid 5 feet apart over the back of the arch, where it passes under the central portion of the prism, and under these longitudinals have been placed, through which heavy bolts, alternately of copper and iron, run down through the masonry of the bench walls, and are securely fixed in the foundation platform underneath. The plan has succeeded fully, having undergone the severest test to which it will be probably subjected, both as to its capacity to pass the water of the creek during freshets and resistance to the bursting pressure due to the maximum head.

The foundations of this structure were carefully concreted; the top of the arch covered over with that material to the depth specified, and every precaution taken to ensure its stability.

Lock No. 25 is the last of the series, and is arranged to suit either the level of Lake Erie or that of the Grand River, which is from 8 to 9 feet higher. The surface of the reach to the north of this lock being, as before stated, 323 feet above datum, it follows that if at any time Lake Erie should drop to its assumed lowest plane of 325, the lift here would only be two feet. The foundation pit being on soft clay, 12 inches of concrete was placed under the cross timbers. The lower wings are extended to carry a bridge for the road from Thorold to Allanburgh. The lock and its wings, extensions, fender cribs, etc., etc., are entirely completed. 850 feet south of this, a guard lock has been built. The rubble extensions of the wings will not, however, be completed until next season.

In the left bank of the canal, a short distance south of the guard lock, there is a towing path bridge with three openings of 24 feet each, across the head of the raceway which leads the surplus water past on the west side and discharges into the canal below Lock No. 25. This channel is 1,060 feet long, and has a bottom width of 75 feet. Across it, and opposite to the line of the bridge over the wings of the lock above mentioned, a large regulating weir has been built. This has nine 4′ x 4′ openings for the passage of the water, instead of six as at all the 23 others hitherto constructed on the new canal. Across the upper wings of the weir, the road which traverses Lock 25 will also be carried. An easy and wide approach to this bridge has been formed on both sides. Below

the weir the raceway is lined with retaining walls of rubble masonry laid in cement, and leading to the point of junction with the canal, where there is a towing path bridge with oblique piers and three openings.

From Lock No. 25 southwards, the canal banks are 25.6 feet high, being formed to suit the two different levels referred to. The general bottom width of 100 feet is, however, preserved throughout. Towards the upper end of section No. 18, the line crosses the valley of the Beaver Dams Creek in heavy embankment. This stream is liable to very violent freshets, at which periods the adjoining flats have been always submerged for a time. The culvert to carry it is 8 feet wide, 5 feet 10 inches high, and 368 feet long. The masonry is first class, and from the level of the floor to the top of the canal embankment above, the height is 38¼ feet. The culvert has been completed and in use for some time. The road bridge at Marlatt's is also finished. The excavation on Sections Nos. 17 and 18 is very heavy, over 560,000 cubic yards of earth having been removed to date.

Lock No. 25 (bridge centre) is 47,604 feet (9 miles) from the foot of the entrance lock at Port Dalhousie. The work of this section can be easily finished next season.

Sections Nos. 19 and 20.

The work of these sections is principally earth excavation, of which about 710,000 cubic yards have been taken out. The masonry amounts to 9,755 cubic yards, and is completed.

This consisted of two road bridges at Allanburgh, one over the new and another across the present canal, in line of one of the streets in the village; a regulating weir, to pass the supply for the present line of navigation, mills, etc.; a small raceway bridge, and two arched culverts. A retaining wall has also been built on the west side of the new canal, from the upper east wing of the guard lock for a distance of 553 feet to the north.

There is a clay dam across the head of the new canal which will remain until the works of the latter are in a position to let in the water. The pile work, fenders, &c., of the Allanburgh bridge, cannot, however, be completed until this dam is removed. South of the Holland Road the earthwork is well advanced, but north of this point the sub-contractors have moved with much energy and economy about five-sixths of all the excavation on the sections. This has been accomplished principally by the use of what is know as the "Judd excavator," which appears to answer the purpose of clay-digging remarkably well.

The works of these sections can easily be completed next year.

Where the two canals diverge, which may be taken as at the dividing line between Sections Nos. 20 and 21, the distance from the entrance lock is 11.83 miles, or a little over four-fifths of a mile shorter than by the present route.

Between the end of the sections and the guard lock a considerable amount of dredging on the bottom and sides has been done to give the full draught required for the enlarged navigation, and to make the curves of approach to either route as easy as possible.

As previously stated, 11 sections of the new canal have been finally estimated. These have been accepted from the contractors, whose responsibility in connection with the work has therefore ceased. The banks of the canal and its reservoirs have, after long exposure, in many cases become deeply furrowed by the heavy rains or melting snows, which rapidly affect the clay of which they are composed. Numbers of the off-take drains

have been blocked up by the silt which eventually finds its way into the bottom of the channel. These matters had to be attended to; and it also became urgent to flood the timber flooring of the lock to keep them from decaying. Low earth-dams with a spill-way in each, have therefore been formed for this purpose, one at the foot of each lock, as directed by you. A force of men and teams were engaged during the past summer and fall in clearing out the ditches, making up parts of the embankments which had sunk behind the masonry walls, etc., etc. This work will have to be resumed early next spring. There are six temporary bridges in use as crossings near the site of the permanent structures, which are not yet begun. These have to be frequently repaired, and the travel over some of them is so extensive that it will be necessary to entirely renew the roadways next season, if not before, to avoid the occurrence of accidents.

The timber delivered for lock gates is stacked on the old Price farm on Section No. 10, and is well protected from the weather by coverings of boards.

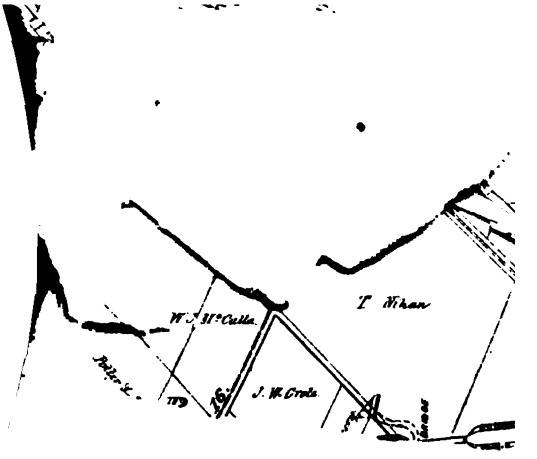
It will, in my opinion, be found of essential service in preserving the banks of the new canal and the earthwork in many places along it, to sow the slopes with certain varieties of grass seed, clover, etc., next spring. This might be done by a comparatively small outlay, and is pronounced by competent persons to be very desirable and easily practicable.

In conclusion, I may state that, in addition to the duties devolving upon me as your assistant in charge of the extensive works above reported upon, I had, by order of the Department, to act as superintendent of the Welland Canal from the 19th of May until the beginning of July, 1879, during the suspension of the present incumbent from his office, pending an investigation into the general management of the work in question.

I have the honor to be, Sir,
Your obedient servant,

THOMAS MONRO,
Civil Engineer.

JOHN PAGE, Esq.,
Chief Engineer Canals,
Ottawa, Ont.


W. J. M.Culla.
T. Wilson
J. W. Cole

APPENDIX No. 14.

WELLAND CANAL.

SPECIFICATION for Excavation at the "Deep Cut," situated between ALLANBURGH and PORT ROBINSON.

This cut is fully one mile and two-thirds in length, and the work for which tenders are invited consists in the removal of a continuous strip along its east side, about 40 feet in width, from the general line of the present slope, at 2 feet over ordinary water surface, or at a line 22 feet over the level of the mitre sill of the lock at Port Colborne. At this depth, and for the width above stated, the excavation is to be made nearly level, and the bank trimmed to a slope of 2½ horizontal to 1 vertical.

All the materials excavated must be transported and spoiled on the east side or in rear of the existing bank, except such portions of them as can be deposited on the low ground at either end of the cut.

The contractor will not be allowed to increase the height of the present banks, or to place any of the newly-excavated material on them, except where necessary to level or fill up such low places or inequalities as may be found in the surface.

The present and new portions of the spoil banks must be connected, and the whole made of an uniform width from the front side of the cut, and all the material placed so that the top shall present a fair surface, with such a declivity outwards from the canal as will readily carry off the surface water; the rear part of the bank to be graded on top (as directed), so as to form a roadway.

The side slope of the new cut must be carefully dressed to the angle before stated, and made so as to present to the eye a fair outline, corresponding to that of the canal.

At the toe of the slope, a ditch from 10 to 15 inches in depth, and 3 feet in width the bottom, is to be formed, with take-off drains leading into the canal at distances of more than 600 feet apart.

On the top of the bank, and within 8 feet of the front edge of the slope, a ditch t 18 inches deep and 3 feet wide at the bottom, with proper side slopes, is to be ed, and from it off-take drains are to be cut to the rear line of the spoil bank.

The materials excavated from these ditches and drains must be placed on the east side of the bank.

When executing the work, it is to be distinctly understood that the part of the spoil bank opposite the middle of the cutting shall be made up *first;* and that care must be taken to prevent any loose material getting into the canal; and that every precaution shall be adopted to guard against anything being done that would be likely to have a tendency to interrupt, impede or in any way interfere with the navigation.

The work throughout must be proceeded with and carried out in strict accordance with the direction of the engineer, or person in charge, and the price tendered per cubic yard must embrace all hauling, clearing, grubbing, and removal of stumps that may be necessary, and also the construction of such bridges, cutting of ditches, etc., as may be required for the contractor's convenience, and every other contingency directly or indirectly connected with the full and satisfactory execution of the undertaking.

The work must be commenced immediately after the contract with the Minister of Public Works shall have been entered into, and proceeded with in such a manner as will insure its completion by the 1st day of July, 1873.

JOHN PAGE,
Chief Engineer of Public Works.

DEPARTMENT OF PUBLIC WORKS,
Ottawa, 7th October, 1871.

APPENDIX No. 15.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTIONS Nos. 21 and 22 of the Enlargement.

These sections are situated between Allanburg and Port Robinson, extend over a distance of 10,000 feet, and embrace that portion of the canal known as the "Deep Cut."

The work contemplated to be done consists in lowering the bottom for the entire distance to 3 feet below the top of the mitre sill of Port Colborne Lock, increasing the width to 100 feet at bottom, and removing from along the face of the west bank a continuous strip of from 45 to 50 feet in width, at 2 feet over ordinary water level.

The side of the bank, over the height above stated, is to be made to a slope of 2½ horizontal to 1 vertical, and the sides of the canal, below the level of the towing path, are to have slopes of 2 horizontal to 1 vertical.

All the materials excavated over the height of 2 feet above ordinary water level must be transported and spoiled on the west side of the canal and in rear of the existing banks.

The contractor will not, however, be allowed to increase the height of the present banks, or to place any of the newly excavated material upon them, except to fill up such low places or inequalities as may be directed.

The present and new portions of the spoil banks must be connected, and the whole made up of an uniform width from the front edge of the cut, and all the material placed so that the top shall present a fair surface, with such a declivity outwards from the canal as will readily carry off the surface water.

The side slope of the new cut must be carefully dressed to the angle before stated, and so as to present to the eye a fair outline corresponding to that of the canal.

At the toe of the slope a ditch, from 10 to 15 inches in depth, and 3 feet in width at the bottom, is to be formed, with off-take drains leading into the canal, at distances not more than 600 feet apart.

On the top of the bank, and within 8 feet of the front edge of the slope, a ditch about 18 inches deep and 3 feet wide at the bottom, with suitable side slopes, is to be formed, and from it off-take drains are to be cut to the rear line of the spoil bank.

The materials excavated from these ditches and drains must be placed on the west side of the bank.

If it is found necessary for drainage to cut a ditch to the westwards of the spoil bank the contractor must do so when requested, and place the clay excavated from it where directed by the officer in charge.

When proceeding with the work, care must be taken to prevent any loose material getting into the canal, and every precaution must be adopted to guard against anything being done that would be likely to interrupt or in any way interfere with the navigation.

It is quite probable that when deepening and enlarging the channel, the bulk of the material excavated or dredged out will have to be transported in scows and wasted in the Niagara River, below the Village of Chippewa, or at some less distant place where the ground is low, and the material will have to be twice handled.

In the event of the contractor wishing to adopt the latter course, and the place selected by him is sufficiently remote from a village, and in other respects not seriously objectionable, the Department of Public Works may consent to this, and assist the contractor in procuring the land for that purpose.

The channel is to be enlarged by taking off a cut, 15 feet in width, along the east side, and one of 25 feet on the west side, so as to make the east side at bottom 40 feet, and the west side 60 feet, from the present centre line.

When about to proceed with the works, the widening on the east side and the deepening of the present channel are first to be undertaken, and the operations commenced near the upper end of Section No. 22.

The contractor must, in all cases, be strictly guided by the lines marked out by the officer in charge, and must take great care not to cut into the inside slopes, nor to do anything that would have a tendency to impair the stability of the banks.

The bottom of the present channel, when deepened, as well as that of the new parts of the works, must be made as level as circumstances will permit, and the side slopes throughout made as uniform as possible.

Above water surface the slopes must be trimmed to the angles already stated, to the lines marked out on the ground, and agreeably to the instructions of the engineer in charge.

On both sides of the canal a towing path is to be formed at the height of 25 feet over the bottom or 22 feet over the mitre sill of Port Colborne Lock. It will be made 15 feet wide on top, and have an inclination of 12 inches outwards to a ditch formed in the rear, or at the toe of the slope of the adjoining bank.

The operation as a whole must be conducted in such a manner as not to interrupt or impede the passage of vessels, or in any way interfere injuriously with the navigation.

and subject to the canal regulations now in force, or such others as may be adopted and sanctioned by His Excellency the Governor-General in Council.

It is to be clearly and distinctly understood that the whole of the work to be done below the level of the towing path, for the deepening and enlarging of the canal on the sections above mentioned, will be measured, computed, and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks) at short distances apart along the whole length and breadth of the work.

A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of dredging, excavation and work done, for which payment will be made.

The prices tendered for the different items of excavation and dredging must cover the entire cost of clearing and mucking seats of banks, *hauling* and *transporting* material, forming banks, and trimming slopes to the required angles, cutting side ditches, and everything necessary for the full and satisfactory completion of the respective works contemplated in the specification.

The contractor must furnish and provide, at his own cost and expense, all excavators, dredging machinery, derricks, scows, plant, tools and labor that may be required to carry on, conduct, execute and complete *one-half* the work, to be done over the water surface by the first day of May, 1874, and the whole of the work above that line by the first day of May, 1875. *One-third* part of all the work under the level of the towing path to be finished by the first day of June, 1873, and *two-thirds* of the whole work under that line by the first day of August, 1875, and the full completion of the entire work on or before the first day of December, 1876.

The party whose tender may be accepted shall be subject to all the clauses and conditions in regard to payments, retained percentage and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada; and to such other special conditions as the nature of the works may in the opinion of the Minister of Public Works seem to demand.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 20th December, 1872.

APPENDIX No. 16.

WELLAND CANAL.

SPECIFICATION of the work to be done on SECTION No. TWENTY-THREE, for which Tenders are invited.

This section extends from a point near the southern boundary of John Coulter's property, on the west side of the canal above the Deep Cut, to a little south of the floating towing path bridge, above Port Robinson, and is about one mile in length.

The work upon it consists chiefly in deepening and widening the channel, removing the abutments of the present swing bridge, and the walls, piles, gates, etc., connected with the old guard lock. It also embraces the construction of abutments and piers for a swing bridge, together with the works and arrangements necessary for a set of guard gates near the north end of the section.

The channel is to be enlarged to a width of 100 feet at bottom, when sunk to a uniform depth of 2 feet 9 inches below the top of the mitre sill of the present lock at Port Colborne; the side slopes throughout to be made two horizontal to one vertical.

At the north end of the section, the widening to be done is principally on the west side, its range forming a slightly curved continuation of the west line of Section No. 23.

In the vicinity of the present swing bridge, the cutting will be on both sides of the channel, but chiefly on the east side, thence upward it will be on the west side, until near the south end of the section, where the widening will be done on both sides.

The sides of the channel will generally correspond with the lines indicated on the plans exhibited, but the Department of Public Works reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly, on either one side or the other, or of increasing the width on both sides, as may be subsequently determined. These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The greater portion of the material excavated can be deposited at some place within the limits of the section, and at a distance of from one hundred and fifty to four hundred feet from the centre line of the canal. Contractors should, however, bear in mind that the dumping ground will not be continuous, but at different places, and may be at or near both ends of the section. They should also keep in view the fact that none of the excavation can be deposited outside the east bank, for a distance of 2,000 feet from the mill at Port Robinson, upward.

The material excavated, when widening on the east side of the canal, at and in the vicinity of the old guard lock, down to the ordinary water line, or as much of it as may be required, must be hauled and placed so as to level up the channel of the old canal on the west side of Front Street, village of Port Robinson, from the bridge on John Street up to near the Collector's Office, or for such other distance as may be required, as the works proceed.

At the south end of the section, or where there is shoal water that can be rendered available for spoiling ground, arrangements must be made for forming a bank at the time of low water, in a position such as will admit of safely placing the soft material in rear of it. To effect this object, the contractor must be prepared to urge on all such parts of the work, between the middle of July and early part of September, when the water in the canal is generally low; and to insure its efficiency, he must remove the soft material for such a depth as may be required, and also form the top with a descent of one foot or more outward from the canal. These parts of the banks must be made of such a width as may be directed, and if possible, be formed of dry material, hauled on to the place in carts or waggons.

Towing Path.—On the west side of the canal the towing path is to be continuous, and on the east side the adjoining banks and all suitable embankments which can be made from the material excavated will be rendered available for that purpose. In all cases where formed in cutting, the front edge will be 99 feet from the centre line, at 24½ feet above the bottom of the canal, or 22 feet over the present mitre sill of Port Colborne Lock.

It will invariably be made 15 feet wide on top, and have an inclination of about 12 inches outward to a ditch at the rear or toe of the adjoining bank.

The ditch to be generally 3 feet wide at top, and the bottom have such an inclination as will carry the surface water freely to off-take drains, formed at such places as circumstances may require.

At all places where the natural ground is below the level required for the towing-path, or banks adjoining the canal, the surface must be removed for such a depth as may be directed, and all stumps, roots and logs cut and cleared away for the entire space to be occupied by the banks.

Spoil Banks.—All standing trees must be cut down, logs and brushwood removed, (or burnt), from the place to be occupied by spoil banks, care being taken in all cases to guard against damaging or interfering with the adjoining property.

They are in no case to be formed on ground where the surface inclines toward the canal, unless level benches are first cut for a foundation. The new material must be kept back at least ten feet from the top edge of the bank slope, and is not to be raised more than ten feet above the level of the towing path, within a distance of 160 feet from the centre line of the channel. Beyond the distance stated the height may be increased, after suitable drains and other provisions are made to carry the surface water to the back ditches.

The banks must, as nearly as circumstances will admit, be made of an uniform height, and invariably have a declivity outwards of at least one in twenty, and throughout be of a regular width.

BACK DITCHES—to carry off the surface water, and such other natural drainage as it may be necessary to provide for, are to be formed at the places and of the dimensions required; care being taken that the old ditches are not interfered with, or the drainage in any way interrupted before the new ditches are fully available.

For any damage that may arise from this cause, whether the result of inattention or otherwise, on the part of the contractor, he will be held strictly and legally liable to the owners of the property.

When conducting the works connected with the enlargement and deepening of the channel, as well as in placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge.

He must also take great care not to cut into the inside slopes, nor do anything at all likely to have a tendency to impair the stability of the banks.

The bottom of the present channel when deepened, as well as that of the new work, must be made as level and uniform as possible, so as to insure throughout the full width and depth contemplated.

Over water surface the slopes must be trimmed to the angles before mentioned, and be made to correspond with the lines marked out on the ground, and agreeably to the instructions of the officer in charge.

GUARD GATES, BRIDGE PIERS, ETC.

At the north end of the section, opposite the lower side of a small island indicated on the plan, or at some other place within a distance of five hundred feet from that mentioned, guard gates are to be constructed for the purpose of keeping the water in the "Deep Cut," when that part of the canal above the outlet to the Welland River at Port Robinson may be empty; the walls of which are to be used to form bearings for the swing bridge intended as a substitute for the present road crossing situated nearly one-fifth ($\frac{1}{5}$) of a mile farther to the south.

The water-way at the place mentioned will be in four divisions, each of the two middle openings being 46 feet in width at the assumed lake level, and the side openings are each to be 18 feet wide. They are to have side walls of masonry laid in hydraulic cement mortar, built chiefly in the form and of the dimensions shown on the plans, and in the manner herein described, or that may be subsequently found necessary.

The walls are to form the seat and abutments of a swing bridge for crossing the two large openings and bearings for a stationary bridge to be built at each side.

To enable the works to be executed between the closing of navigation one year and the opening of it the following spring, a dam must be formed across the canal at a place a short distance north of where they are situated. This dam must be made the full height of twelve feet above the present mitre sill of the lock at Port Colborne, and be formed in such a manner that it can be quickly removed at the usual time for opening the canal.

A small dam on the up-stream side will also, in all probability, have to be formed to enable the works to be unwatered. These dams should be at least 250 feet apart, as

it will be necessary to deepen a stretch of 110 feet on both the upper and lower sides of the contemplated swing bridge, to the full depth of 4½ feet below the mitre sill of Port Colborne lock, and to such a bottom width as a suitable approach to the bridge openings may require.

The pit for the foundation of the guard gates, etc., will be 192 feet in breadth across the channel, and 30 feet in length, or, of such other dimensions as may be necessary to admit the respective walls, wings, etc., represented on the plan.

The upper 13½ feet in length of the foundation for the entire breadth will be sunk to the depth of 7 feet below the top of the mitre sill of Port Colborne Lock, and the other part (16½ feet) of the length, will be sunk 2½ feet lower, or to a depth of 9½ feet below the point above mentioned, and to such slopes as may be required for the stability of the banks during the execution of the work.

At the respective depths above stated, the bottom throughout must be made fair and level to receive the foundation timbers, etc.

From the lines of the sides and bottom of the present canal, downwards, for the area mentioned, the excavation will be considered as for the guard gates and swing bridge; the material from which must be hauled and placed on the low ground in the vicinity, at such places as may be directed on either side of the canal, within a distance of 700 feet from the centre line.

The south half of the bottom for the guard gates, for its entire breadth and length, is to be covered with a bed of concrete, 18 inches in depth; but for about 3½ feet adjoining the recesses for the gates, its depth will be at least 3 feet.

When doing this part of the work, the concrete, after it has been prepared as herein described, must be dropped from a staging placed about the level of the towing path, and the surface made up to the proper height before the cement sets.

PLATFORMS—are to be laid over this part of the bottom, made up of pine timber 12 inches square and 56 feet in length, arranged when in place to be 18 inches and 9½ feet, alternately, under the side walls of the respective openings. All of them must be counter-hewn, well dressed with a plane and laid to water-tight joints for their entire length and depth. They are to be placed in full beds of mortar and be secured by three wrought iron screw-bolts (1½ inches diameter), passing horizontally through the platform. The ends of them must have double nuts and washers, in order to form a connection with shackle-bolts, passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or a block of masonry built for that purpose. The platforms for the small or side openings are to be on the same continuous range, made in a similar manner but with only one horizontal bolt through each of them.

The lower timber, or that next the gate, in each case must be of white oak 14 x 15 inches, checked on top to receive the ends of the flooring, and also on the horizontal quoin-pieces in which the gates are to work. These quoin-pieces are also to be of white oak timber, 16 x 18 inches, and have the lower upper edge hollowed out for the gate, as shown on plan; under them there are to be two other timbers, the lower one of which is on the same plane as the timbers that form the foundation of the lower part of the structure.

The oak piece at the lower side of the platform, the quoin-pieces and other timbers which form the breast of the horizontal recess for the gates, are to be secured to each other vertically by six wrought-iron screw bolts, 1¼ inches diameter. The quoin and other breast timbers of each of the side openings are to be fastened in like manner with two vertical bolts.

The timbers of the recess must also be of pine 12 x 12 inches and 56 feet in length, laid six inches apart, except at the lower side, where the outer two timbers are to be jointed and laid close, and arranged so that in each case one end shall be alternately 18 inches under the side walls.

The spaces between the timbers in the recesses, as well as those under the walls, are to be filled with concrete.

The breast, at the lower side of each of the recesses, is to be carried 3 feet over the adjoining floor, by means of three ranges of 12 x 12-inch pine timber, of a length to extend at least 18 inches into the side walls; the upper range to be 14 inches in width and have its inside edge bevelled, as shown on plan. These timbers are to be connected with the foundation timbers under them by six wrought iron screw-bolts, 1¼ inches in diameter.

SHEET PILES.—Three trenches are to be cut across the foundation for the reception of sheet piles, one at each end of the structure and another adjoining the quoins for the gates; they are to be sunk at least 4 feet below the foundation timbers, and are not to exceed 2½ feet in width. One side of each trench must be cut plumb and fair, so as to afford an even bearing to the piles for their entire depth.

The sheet piles are to be of 4-inch plank, in lengths of 5 feet at least, well jointed with a plane, and have the edge of each plank chamfered on the side next the trench. They are to be placed vertically to close joints, fastened to the anchor and foundation timbers with 8-inch pressed spikes. The trenches must then be filled with puddle, made of the best description of material that can be obtained in the vicinity for that purpose, or they must be filled with concrete, if so directed.

In each of the large recesses, six horizontal timbers of pine 10 x 12 inches are to be placed, about equal distances apart, 4 inches over the floor, one end of each piece is to be dovetailed between the middle timbers of the lower breast, and the other end boxed into the timbers of the upper breast and secured to the foundation timber with rag-bolts.

On the inner side of the lower breast, triangular blocks are to be placed in three of these divisions, through which eye-bolts, 2 inches diameter, (for the knuckle jointed bars of the gates) are to pass obliquely down through the outer floor timber, and have at the lower outer angles of the latter, suitable screws, washers and nuts.

In the centre of each of the small openings, there will be one knuckle-jointed bar and an eye-bolt of a like size, secured in a similar manner as above described.

FLOORING.—The entire area of the foundation is to be covered with a course of pine plank, 2 or 3 inches in thickness, as may be directed. All of them must be well jointed with a plane and driven up with wedges to water-tight joints and of the full length of the floor or recess. They are to be fastened with white oak treenails, 1½ inches diameter and (according to the thickness of the plank) from 7 to 9 inches long, two in each end of a plank and one on alternate sides at every crossing of a timber; none of the planks to exceed 12 inches in width.

MASONRY.—The piers and abutments which are to form the sides of the guard gates, the seat of the swing bridge and stationary structures at both ends of it are to be 29 feet in length, and they, as well as the rest piers, fender ranges, etc., are all to be built parallel to the centre line of the canal and carried to a height suited to the top line of the present towing path.

The centre pier is to be 24 feet high and, from its upper end to the line of the gates, will, at the level of the platform, be 19½ feet in width, where an offset, or square recess, of 2½ inches in depth on both sides of it, reduces the width to 15½ feet.

Below this line, the face of the recess wall will in each case project 12 inches, the upper part of which will be chamfered 4 x 7 inches, to form a bearing for the gates when the water-way is clear.

Through the middle of this (centre) pier, at about 5 feet over canal bottom, a sluice-way or culvert 5 feet wide and 6 feet high, to the springing line of the flat arch over it, will be formed in the direction of the channel.

At a point near the centre of the recess, immediately over the foundation floor, an opening 12 x 18 inches is to be formed in and through the wall transversely, and over it a well 18 x 18 inches is to be carried up to the bottom of the sluice-way.

The piers that are to form the seat for the ends of the swing bridge, as well as the sides for the guard gates, are to be 11½ feet wide at the level of the platform, carried up on the face and arranged in every respect as described for the centre pier; except that on the east side of the east pier and on the west side of the west one the recesses will only be made 19½ inches deep at bottom.

That part of them which forms the direct bearing for the toe of the swing bridge will in each case be carried up to about 23 feet over canal bottom; but the parts which form a seat for the fixed girders of the roadway are to be carried 4 feet higher, and on them parapet piers are to be built for an entrance to the bridge.

The abutments for 12½ feet over the level of the platform, will, in the middle portion, be formed of two walls; the outer one 5½ feet thick at the level of the platform will be carried up to a batter of one in twenty-four on the face and be recessed in like manner as the opposite side wall of the water-way; the rear wall will be 3½ feet thick, made convex towards the bank, and the space (4½ feet) between the two walls will be filled with concrete.

At 10½ feet from each side of the bridge crossing, the abutments are to be carried up plumb to 12½ feet over canal bottom, and this part of the face (4 feet at each end) will have a batter of 5½ feet from the bottom to the height above stated. At this line, the wing walls will be 6 feet thick—be stepped up toward the outer end as circumstances may require, and both they and the abutments, at the level of the roadway, are to have frost batters in the rear.

At all four corners of the bridge, parapet piers are to be built 4′ 10″ x 3½ feet at base, diminishing upward.

The wings of the abutments are also to be carried up to the same height as the parapet piers and finished with coping as indicated on the plans.

The walls above and below the abutments, for a distance of 40 feet or more, are to be of rubble masonry, arranged to wind gradually round to meet the line of the slope on the respective sides.

To carry the ends of the swing bridge when open, rest piers 9 feet long and 14 feet wide, of masonry, are to be built in the positions indicated on the plan and, in the centre of each of them, a culvert 5 feet wide and 6 feet high to the springing of the arch is to be made on a line ranging with that of the channel. The seats of them must be sunk at least one foot below canal bottom, or more if it is found necessary to place them on a foundation of timber or on a bed of concrete.

All the piers, side walls, wings and other parts of the masonry are to have a batter of *one* in *twenty-four* on the face, sides and ends, except the recesses for the guard gates, which are to be carried up plumb.

The arch stones of the culverts are to be 18 inches deep, dressed to radiate truly for their full depth and made to lay throughout to joints of one-fourth ($\frac{1}{4}$) of an inch.

The sides of the water-way must also be dressed on the face and laid to *one-fourth* of an inch joints, and have the bottom formed of properly-jointed stones of a size that two of them will make up the width of the opening and at each end pass at least 12 inches under the wall.

The face stones of the centre pier, sides and ends of the wall, for the guard gates, abutments, wings and other facework, together with that for the sides and ends of the rest piers of the swing bridge, must be two and three feet depth of bed in the alternate courses, with headers in every course $4\frac{1}{2}$ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay invariably to joints not exceeding one fourth ($\frac{1}{4}$) of an inch, and the faces of them must in all cases be picked or scabbled to a fair surface; this should be understood as applicable to all parts of the work not otherwise described.

The heart of the walls in all cases, as well as the backing of the abutments, must be of flat-bedded stones not less than four feet area of bed, and generally of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid, the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints be not more than one inch and a quarter.

The stones for the recess quoins are to bond at least 18 inches over each other, and in every third course the quoin must be of sufficient size to admit of cutting the inner angle out of the solid and still leave the face $2\frac{1}{2}$ feet in length, besides having a face of at least 12 inches in the recess; at 12 feet over canal bottom the angle of each recess is to be taken off obliquely and in this way continued upward for the full height of the wall.

In the face of the piers, on each side of the middle openings, checks are to be formed, and in every third course cut out of the solid 9 x 12 inches from the top down to about 8 feet over the platform, for the reception of projecting fender timbers. Checks are also to be cut about 13 inches over the lower side of the quoin, in the angle of each of the recesses, for the purpose of inserting anchor blocks to keep the gates in place.

COPING STONES—for all the piers must be at least 15 inches in depth, of a size that two stones will make up the width of the piers which form the seats and rests of the bridge, and in each case break joint properly with the course underneath. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout and dressed to lay to joints not exceeding one-fourth ($\frac{1}{4}$) of an inch, and the top side must have a fair, neatly boucharded surface and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed; the space between it and the outer range of coping must be filled with stone of the same thickness as the latter; properly dressed and jointed to the width, and be at least $3\frac{1}{2}$ feet in length.

In the centre of the rest piers, one of the coping stones, for a width of 4 feet, is to be 24 inches in depth and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts $1\frac{1}{2}$ inches in diameter let into the masonry underneath.

The coping on the piers for the seat and the abutments of the bridge will be 10 inches in thickness at centre of the road, curved on top so as to be 8 inches at the sides, placed to form a recess for fixed girders and made to the same curve as the rear of the offset below for the toe of the swing.

FENDERS—are to be constructed on both sides of the water-ways, extending for some distance above and below the bridge as represented on general plan. They are to be formed by means of piles, caps, diagonal braces and wale pieces, all of white oak timber. The piles to be not less than 12 inches diameter at the small end, driven from 6 to 10 feet into the bottom, three in a group, at about 12 feet from centre to centre, and one at the intersection of the diagonal braces. The caps to be formed of two pieces each 6 x 10 inches, arranged about 8 inches apart, and checked obliquely to receive a dovetail formed on the heads of the piles, to each of which they will be secured with wrought iron screw-bolts seven-eighths ($\frac{7}{8}$) of an inch diameter, having upset heads and cast iron bevelled washers let flush into the outside cap-pieces.

Immediately under the caps, the cross-ties will connect with a dovetail the outer piles and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter. The cross-ties to bear on the inside piles and the ends extend to the outer side of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same pile with a screw-bolt $1\frac{1}{8}$-inch round iron, with upset heads and washers, sunk flush as described for the cap-pieces. Where the wale pieces are scarfed they must be secured to the outer piles also with screw-bolts $\frac{7}{8}$ of an inch diameter, with heads, nuts, etc., as stated for the others. At 7 feet below the top of the cap-pieces another range of waling 8 x 10 inches is to be put on and fastened throughout with bolts in like manner as for the upper tier.

Diagonal braces 10 x 12 inches are to be framed on to the ends of the cross-ties, half checked in and on to each other where they intersect, and be secured to the top of the centre pile with a rag-bolt 20 inches long and $1\frac{1}{8}$ inches diameter. At the toe these braces are to be secured to each other by means of a screw-bolt 1 inch diameter passing through them and the cross-ties, bevel washers suited to the angle being used.

The inside cap-pieces are to extend from the lower end to the upper side of the recess, and the face cap-pieces will be continuous and connected with the fender timber previously mentioned as checked into the face of the pier.

The anchor timbers to be dovetailed between the piles in like manner as stated for the cross-ties and let into the bank for such a distance as may be required, where they will be fastened to a cross-timber.

For the protection of the bridge and piers a cluster of ten or more piles will be driven in the centre of the canal at a suitable distance above and below the range of the bridges when open; they are to be connected by means of thorough bolts, straps, etc., and stand fully one foot over the cap-pieces.

The change in the location of the swing bridge will render necessary the formation of about one-fifth of a mile of new road on the west side of the canal, and for a short distance on the east side a new line must also be made.

These portions of the road must be graded longitudinally and rounded transversely in a satisfactory manner, have ditches of suitable dimensions, with good bottom inclinations formed on both sides and be connected with three or more culverts of 3-inch pine plank, from which such off-take drains are to be cut as may be required to carry off the surface water.

A bridge must also be built over the back water on the west side of the canal, with such openings as may be necessary for the free passage of the water during freshets. It may have stone abutments with bents in the middle to carry the stringers of the roadway, which are to be covered with plank and have a suitable railing on each side, or the bridge may be built wholly of timber, as may be required.

CONCRETE—where used, must consist of an approved quality of stone broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand in such proportions as may be required.

MORTAR.—The whole masonry for guard gates, piers and abutments of bridge must be laid in mortar made of the best hydraulic cement mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory and, until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use and it must be prepared under the directions and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half (1½) of clean, sharp sand to one of cement and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

The contractor must construct dams wherever it may be necessary to keep out water during freshets, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with unwatering the works during their progress and up to the full completion of the whole; and the satisfactory removal of all coffer dams and other temporary works must be embraced in the bulk sum stated in the tender for unwatering the works.

STOP GATES—of solid timber are to be built in one piece, adapted to the respective openings and arranged for 12 feet in height over canal bottom; when not in use they are to occupy a horizontal position in the recesses formed in the bottom

for that purpose. Those for the main openings are to be 47½ feet long, and for the side openings they will be 19 feet long, and all of them are to be 14½ feet wide.

The bottom or heel pieces of each of the gates to be of white oak timber 16 x 16 inches and about 50 feet long, one side of which is to be rounded to a radius of 8 inches to work in the hollow of the horizontal quoin piece previously mentioned, and for about one foot at each end it will be made round, the full size of the timber, to form bearings for the gates.

All the other bars are to be of pine timber, varying from 12 to 16 inches in thickness and from 9 to 12 inches in depth. They must invariably be of the full length and thickness of the gates, and be accurately dressed and planed to the uniform parallel depths above stated, to form water-tight joints when in place, as well as a fair face on both sides. They are to be put together with dowels 2½ inches diameter and 3 inches long, let in 1½ inches, and fitted tightly into the timbers over and under them. The dowels are to be about 3 feet apart and arranged on alternate sides of the centre line of the timber. The bars of the gates are to be fastened together by means of six (6) wrought iron thorough bolts, each one and a half (1½) inches diameter, and two (2) bolts of a like size in each of the side gates, arranged as shown on plan, having nuts and washers at both ends boxed into the bottom and top-pieces.

The gates are to be strengthened by posts 10 x 14 inches, placed at right angles to the bars; six posts to each of those in the main openings and two to each of the side openings.

The bars and posts to be connected by means of wrought iron screw-bolts, seven-eighths (⅞) of an inch in diameter, the heads to be upset, and the washers for them to be countersunk and let in flush on the upper sides of the gates. In each post there will be 10 bolts arranged so that for the first five feet over the platform they are to be not more than one foot apart, above which they will be from 18 to 24 inches apart.

The gates for each of the main channels to be further stiffened at top by means of a jointed truss-bar of 3½ x ⅝-inch iron reaching across the gate and the ends of the truss, to be connected with ring-bolts for raising or lowering the gates. One hinged-jointed strap to be fastened in the centre of each of the side gates for the purpose of raising or lowering it.

To support the gates when in motion, tamarac knees are to be fastened to the floor timbers of the recesses with rag-bolts—six knees in each of the large openings and two in each of the side openings.

Anchor timbers to form the upper part of the bearers for each end of the gates are to be let into the checks cut for their reception and secured with two wrought iron fox-wedged bolts let into the offsets which form the gate seat.

For the protection of the joint between the gates and horizontal quoin a double-hinged cover of boiler plate iron is to be placed over it in such a manner as will form a protection whether the gates are in a vertical or horizontal position. To guard against injury to this cover, or to the gates when open, a bar of 4 x ⅝-inch wrought iron is to be bolted on to the top of the cross sill over the quoin piece.

The knuckle bars to be 3½ x ⅝-inch wrought iron made with three joints, one at the bottom, another near the middle, and a third at the top, each joint to be formed with double claws and made to receive a two-inch pin, without in any way diminishing the full strength of the bar, and arranged to work freely. To form the connection at the

upper side a bolt with a double eye will pass through the third bar from the top, and also through a plate of wrought iron, which together with the nut must be flush with the face side of the gate.

The necessary pulleys and opening chains for the gates must be provided by the contractors.

In the side openings a place must be left in the offset which forms the seat of the gates for the insertion of a 6-inch pipe, from which a space 6 inches square at the bottom line must extend through the offset.

SLUICE GATE—to be built of the best quality of white oak plank, 6 inches thick at the centre and gradually rounded off on both sides to $3\frac{1}{2}$ inches at the end. The gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths ($\frac{7}{8}$) of an inch in diameter passing through it, and to have straps of wrought iron 3 inches wide and three-eighths ($\frac{3}{8}$) of an inch thick on both sides of it, within three inches of each end; the straps are to be let in flush and fastened at distances not more than 6 inches apart, with rivets $\frac{1}{2}$ an inch in diameter countersunk into the straps. The top plate is to be $2\frac{3}{4}$ inches deep, and that at the bottom $6\frac{1}{2}$ inches deep, each to have a flange from the centre outwards on opposite sides.

The gate is to revolve on the centre on a pivot working into the bottom plate of the gate, and on the top of it a disc of steel or hard brass is to be placed, and have a brass collar and lining. The pivot is to be $3\frac{1}{2}$ inches diameter, connected with a plate 9 inches square and 2 inches thick let into the sills of the sluice-way and secured to them by fox-bolts.

The gate is to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with anchor bolts built into the masonry.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gate when closed, and stops are to be placed in the interior as directed.

The turning rod is to be of wrought iron 3 inches diameter, of sufficient length to pass through the gate and stand 6 inches over the coping of the pier. It is to be keyed into the plates on the gate and secured to the masonry with suitable iron brackets, the upper end of it to be made square, on which a movable handle is to be fitted, and is further to be connected with racks on the pier made so as to secure the gate in the position required.

All the wrought iron used in connection with the gates must be of the best and toughest kind of refined English or Canadian iron; the castings must also be of the best quality; and both the wrought and cast iron work must be prepared and fitted up in the best manner, by turning, filing or otherwise as may be required to ensure the description of work contemplated in the plans and foregoing specification.

The iron work must be heated to such a temperature as may be required, and receive a bath of coal tar or linseed oil before being put in the work.

The timber must also be of the best quality, sound, straight-grained, free from sap, shakes, unsound knots and other defects, and the work executed in a substantial, satisfactory and workmanlike manner.

All the wood-work must be put together with white lead and oil, which must be used freely in every joint and dowel between the bars, between the binders and bars, at all

mortises and tenons and at every place where two surfaces of wood or of wood and iron come in contact.

The removal of the masonry of the guard lock at Port Robinson is to be tendered for by the cubic yard, which must include hauling and depositing the material where directed within a distance of 700 feet.

The removal of the guide piles, waling and other timbers at ends and sides of the lock, the present swing bridge and its abutments, the old lock gates, mitre sill and the foundation timbers, etc., of the lock are all to be embraced in one bulk sum, which must include the entire removal of all timber and iron work connected with the old guard and swing bridge, hauling and placing them where pointed out within a distance of 700 feet, where all the materials, timber, iron, and stone are to remain the property of the Department of Public Works.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal on the section above mentioned will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all that portion of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks) at short distances apart along the whole length and breadth of the work. A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done for which payment will be made.

The bulk sum tendered for unwatering the works must embrace the cost of constructing all coffer dams required to keep out the water and to guard against leakage, springs or surface drainage, together with the expense of pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with unwatering the foundation or any other portions of the works during the progress of the operations and up to the full completion of the whole undertaking, and the satisfactory removal of all coffer dams and other temporary structures at or before the usual time of opening spring navigation.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality and all such parts of the structures as may be required will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, &c.—The Contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads or for the placing or preparing of materials beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work as contemplated in this specification.

All the materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

The operations must be conducted in such a manner as not to interrupt or impede the passage of vessels, or in any way injuriously interfere with the navigation, and

subject to the canal regulations now in force or such others as may be adopted and sanctioned by His Excellency the Governor General in Council.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract satisfactory security will be required on real estate, or by a deposit of money, public or municipal securities or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 1st day of April, 1877.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 3rd June, 1875.

APPENDIX No. 17.

WELLAND CANAL.

GENERAL SPECIFICATION of work to be done for the Enlargement, between PORT ROBINSON and WELLAND.

This part of the line embraces Sections Nos. 24, 25 and 26, each about one mile in length, upon which the work to be done consists in widening and deepening the channel, forming towing-path, ditches, off-take drains, roads, etc. On Section No. 25, the abutments, fenders, etc., connected with two swing-bridges are to be removed, and the piers, abutments, etc., for one swing-bridge, or probably those for two, are to be built.

The canal is to be made 100 feet wide at bottom when sunk to an uniform depth of 2¾ feet below the top of the mitre sill of Port Colborne Lock. The side slopes throughout are to be made two horizontal to one vertical.

To make the channel of these dimensions the increased width must be taken off at such places, on either side or on both sides, as may be directed, and the bottom of the existing channel must also be sunk from 2 feet 9 inches to 3 feet throughout.

The material excavated can generally be placed on the same side of the canal as that on which the widening is done, or at some other place within the limits of the respective sections, but it is not to be deposited at any place within a distance of one hundred and fifty feet from the centre line of the canal.

Contractors should bear in mind that the spoil ground will not be continuous, but at detached places, and may be at or near the ends of the section. They should also keep in view the fact that none of the excavation can be deposited outside of the east bank, for a distance of two-thirds of a mile from the upper end of Section 26.

On Sections 24 and 25 the canal will generally be widened on the east side, and for about one-fourth of a mile at the lower end of Section 26, the increased width will be taken off both sides, thence upward it will be taken off the west side.

The side lines of the channel will generally correspond with those indicated on the plans exhibited, but the Department of Public Works reserves to itself the right of

changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides as may be subsequently determined. These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress without giving cause for any increase or diminution of the prices tendered for the respective items of work.

Contractors have an opportunity of examining, on the banks, the nature of the material that has been taken out of the bottom of the present canal on the different sections; still it may be stated for their information that it is generally of a hard nature, especially in the vicinity of Burgar Bridge, and at the south end of Section 24, as well as at several places on Section 26.

Attention is drawn to this important matter at this time so that contractors may look into it carefully and, with a knowledge of the facts, be enabled to determine for themselves the value of the work to be done.

At the north end or other places on Section 24, or wherever there is shoal water that can be rendered available for spoiling ground, arrangements must be made for forming a bank at the time of low water, in a position such as will admit of safely placing the soft material in rear of it.

To effect this object, the contractor must be prepared to urge on all such parts of the works between the middle of July and the early part of September, when the water in the canal is generally low; and to insure its efficiency, he must remove the soft material for such a depth as may be required; also to form the seat with a descent of one foot or more outward from the canal.

These parts of the banks must be made of such a width as may be directed, and, if possible, be formed of dry material, hauled on to the place in carts or waggons.

Towing Path.—All the works connected with the widening and deepening on the different sections must be carried on in such a manner that the present towing path shall not be interrupted, or any part of it interfered with during the season of navigation, unless a new and convenient line be formed at that place or other approved arrangements be made by the contractor (at his own cost and expense) to enable the towing service along that part of the canal to be satisfactorily performed.

On both sides of the channel the towing path is to be continuous. Where necessary, it will be made up of material from the excavation after the seat of the bank has been formed as previously described, and where the water is deep the seat must be prepared by dredging if so directed.

At all places where formed in cutting, the front edge will be 99 feet from the centre line at 24½ feet above the bottom of the canal, or 22 feet over the present mitre sill of Port Colborne Lock.

They (the towing paths) will invariably be made 15 feet wide on top and have an inclination of about twelve inches outward to a ditch at the rear or toe of the adjoining banks.

The ditch to be generally 3 feet wide at top, and the bottom have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

At all places where the natural ground is below the level required for the towing-path or banks adjoining the canal the surface must be removed for such a depth as may

be directed, and all stumps, roots and logs cut and cleared away for the entire space to be occupied by the banks.

Spoil Banks.—All standing trees must be cut down, logs and brushwood removed (or burnt) from the place to be occupied by spoil banks, care being taken in all cases to guard against damaging or interfering with the adjoining property.

They are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut for a foundation. The new material must be kept back at least ten feet from the top edge of the bank slope, and is not to be raised more than 10 feet above the level of the towing path within a distance of 160 feet from the centre line of the channel. Beyond the distance stated the height may be increased after suitable drains and other provisions are made to carry the surface water to the back ditches.

The banks must, as nearly as circumstances will admit, be made of an uniform height and invariably have a declivity outwards of at least one in twenty, and throughout be of a regular width.

Back Ditches—to carry off the surface water and such other natural drainage as it may be necessary to provide for are to be formed at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available.

For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

To form an outlet for the ditches and for the water which collects in low places on the west side of the canal, wells are to be sunk in connection with the ditches, from which off-take drains or culverts are to be made with such inclinations as will discharge the water freely into the canal two feet or more below the assumed level of Lake Erie.

These wells will be from 2 to 3 feet square, and the culverts from them are to be from 15 to 24 inches square. They are to be built of rubble masonry laid in cement mortar, but the bottoms of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least 6 inches under the walls on both sides; the covering of the culvert must also be of flat stones of a length which will bear at least 6 inches on the side walls. The wells and channels from them may, however, be formed of timber and plank and a bridge be made over the outlet if so directed. In either case the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When conducting the works connected with the enlargement and deepening of the channel, as well as in placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge.

He must also take great care not to cut into the inside slopes nor do anything at all likely to have a tendency to impair the stability of the banks.

The bottom of the present channel when deepened, as well as that of the new work, must be made as level and uniform as possible, so as to ensure throughout the full width and depth contemplated.

Over water surface the slopes must be trimmed to the angles before mentioned and be made to correspond with the lines marked out on the ground, and agreeably to the instructions of the officer in charge.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal on the sections above mentioned will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all that portion of the ground to be removed over the water surface, and accurate soundings made, (with reference to fixed and permanent bench marks) at short distances apart, along the whole length and breadth of the work. A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

Section No. 25, as previously stated, embraces the removal of the abutments, piles, fenders, etc., of two swing bridges, and also the bridges themselves, the works connected with which are to be proceeded with at the time and in the manner directed.

At the lower place represented on the general plan (Quaker Bridge) the abutments and piers for a new structure are to be of masonry, laid in hydraulic cement mortar, built chiefly of the form, dimensions and in the manner herein described or that may be subsequently required.

The centre and rest piers of the bridge are to be parallel to the centre line of the canal, the former 16 feet square and the latter 16 feet in width and 11 feet thickness at bottom. An arched culvert 6 feet wide and 8 feet in height will be made through the centre of each pier on a line ranging with the canal. They are to be built on a foundation of timber and plank, the top of which must be at least 5 feet below the present mitre-sill of Port Colborne Lock. On the lower course of the masonry, on all four sides of the centre pier, there will be an offset of about 6 inches, thence the sides are to be carried up vertical. The rest piers at both ends of the bridge are to have a batter on all sides of one in twenty-four.

The arch stones of the culverts are to be 21 inches deep, and dressed to radiate truly for their full depth and made to lay throughout to joints of one-fourth ($\frac{1}{4}$) of an inch. The bottom of the arch or water-way to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening and at each end pass 15 inches under the wall, the second course to project 1 foot into the opening and the third course 6 inches.

The face stones of the piers to be 2 and 3 feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth ($\frac{1}{4}$) of an inch and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of each of the centre as well as the guide piers.

The heart of the wall in each case to be made up with flat-bedded stones not less than 4 feet area of bed and of the full height of the face stone; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints not be more than 1¼ inches.

The piers for the seat of the bridge are to be 21 feet long, 10 feet wide at bottom, and laid on a foundation of timber and plank at a like depth as stated for the other piers.

At 3 feet over bottom, on the channel side, an offset of 6 inches will be made in the wall, over which the face and also the two ends will be carried up plumb, and the side next the abutment, from the foundation upward, will have a batter of one in twelve.

The abutments are to be 20 feet or more distant from the bridge piers, and the foundation of them laid at 5 feet over canal bottom or at such other level, either above or below that point, as circumstances may require. They are to be 7½ feet or more in thickness, carried up to a batter of one in twelve on the face to water line and made plumb in the rear to within 4 feet of top, thence the wall will diminish to the rear line of the coping, which will be 3 feet in width. The face work to be similar to that described for the piers, and the backing of large-sized, well-shaped stone, laid level in full mortar and properly bonded throughout the wall.

The centre piers, piers for seat and rest of bridges, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridges and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top side must have a fair surface, neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed; the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones, for a width of 4 feet, is to be twenty-four inches in depth and checked to the curve of the toe of the bridge. This stone, in each case, must be secured with fox-wedged bolts 1½ inches diameter let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge will be 10 inches in thickness at the centre of the road, curved on top so as to be 8 inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward, one of which at each end of the bridge must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers, and finished with coping, as indicated on the plans.

The walls above and below the abutments, for a distance of 40 feet or more, are to be of masonry, arranged to wind gradually round to meet the line of the slope on the respective sides. The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart; and, for the other piers and abutments, they are to be laid either longitudinally or transversely, as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete, as may be directed.

The covering plank to be of pine, three inches thick, and must be fastened to the timbers with 1¼-inch white oak treenails 8 inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

FENDERS—are to be constructed on both sides of the water-ways, extending for some distance above and below the bridge, as represented on general plan. They are to be formed by means of piles, caps, diagonal braces and wale pieces, all of white oak timber; the piles to be not less than 12 inches diameter at the small end, driven from 6 to 10 feet into the bottom, three in a group, at about 12 feet from centre to centre, and one at the intersection of the diagonal braces. The caps to be formed of two pieces, each 6 x 10 inches, arranged about 8 inches apart, and checked obliquely to receive a dovetail formed on the heads of the piles, to each of which they will be secured with wrought iron screw-bolts seven-eighths ($\frac{7}{8}$) of an inch diameter, having upset heads and cast iron bevel washers let flush into the outside cap-pieces.

Immediately under the caps the cross-ties will connect with a dovetail the outer piles, and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter. The cross-ties to bear on the inside piles, and the ends extend to the outer side of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same pile with a screw-bolt, $1\frac{1}{8}$-inch round iron, with upset heads and washers sunk flush as described for the cap-pieces. Where the wale pieces are scarfed, they must be secured to the outer piles also with screw-bolts seven-eighths of an inch diameter, with heads, nuts, etc., as stated for the others. At 7 feet below the top of the cap-pieces another range of waling 8 x 10 inches is to be put on and fastened throughout with bolts, in like manner as for the upper tier.

Diagonal braces 10 x 12 inches are to be framed on to the ends of the cross-ties, half checked in and on to each other where they intersect, and be secured to the top of the centre pile with a rag bolt 20 inches long and $1\frac{1}{8}$ inches diameter. At the toe these braces are to be secured to each other by means of a screw-bolt one inch diameter passing through them and the cross-ties, bevel washers suited to the angle being used.

The anchor timbers to be dovetailed between the piles in like manner as stated for the cross-ties, and let into the bank for such a distance as may be required, where they will be fastened to a cross timber.

For the protection of the bridge and piers, a cluster of ten or more piles will be driven in the centre of the canal, at a suitable distance above and below the range of the bridge when open; they are to be connected by means of thorough bolts, straps, etc., and stand fully one foot over the cap-pieces.

In case that piles cannot be driven sufficiently into the bottom to form the necessary foundation for the bridge, framed bents of white oak timber 12 x 12 inches may be used for that purpose. To enable the latter plan to be carried out, a trench must be cut 3 feet below canal bottom for the reception of sills, into which the posts of the bents are to be securely fastened.

At bottom of canal and about 10 feet over it, the posts are to be connected with horizontal ties, and, both longitudinally and transversely, ranges of diagonal braces are to be framed vertically in between them and well secured with straps and bolts.

At top the posts are to be connected with caps, ties and wale pieces, framed, bolted and secured as previously described.

If considered necessary, the bearings for the fenders are to be of crib work, through the middle of which a water-way must be formed longitudinally. The cribs to be made

of pine timber—face and end timbers 11 x 11 inches and ties 10 x 11 inches. They are to be laid 1½ inches apart, dovetailed at the corners, and the ties are to be dovetailed between the face timbers and secured with rag-bolts.

The water-way through each is to be formed by means of longitudinal side-pieces connected to the face timbers with short ties, and have such floor and covering timbers placed at suitable heights as may be required.

All the interior spaces in the cribs, except those for the water-way, to be filled with a good class of small-sized stone ballast.

CONCRETE.—where used, must consist of an approved quality of stone, broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand in such proportions as may be required.

MORTAR.—The whole masonry of the bridge piers must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and, until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the directions and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half (1½) of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar, or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

If satisfactory arrangements can be made with those directly interested, Burgar Bridge will not be rebuilt, but a road will be made on the west side of the canal to accommodate the public travel crossing by way of the Quaker Bridge. In case it is found that both of these bridges must be continued, their respective piers and abutments

will be similar, and the contractor must be prepared, on getting six months' notice, to construct those for Burgar Bridge at the same rates and prices as stated in the tender for Quaker Bridge.

The preparations of materials for the piers, etc., of a new swing bridge at Burgar Road is, however, not to be proceeded with until after the contractor has received an official notification to that effect.

In either case, after due notice has been given, all necessary materials must be provided, delivered and prepared so that the works can be done between the closing of navigation one year and the opening of it the following spring or during the winter, in which the water will be drawn down as low as possible, for these and similar purposes.

For about 110 feet on the upper and lower sides of where the bridge is to be built, the excavation required to be done for the widening and deepening, preparing foundations of piers, etc., will be measured, estimated and paid for as bridge-pit excavation.

The road contemplated to be formed as in some measure a substitute for Burgar Bridge, will be in the rear of the spoil bank on the west side of the canal and about two-thirds of a mile long. It must be raised where necessary with material from the canal excavation, or cut down as may be required to an uniform grade longitudinally, rounded transversely in a satisfactory manner, have ditches cut on both sides of such dimensions and with such bottom inclinations as may be required for efficient drainage.

Culverts under the road bed are to be made to connect the side ditches; when of small dimensions they are to be formed of 3-inch pine plank, but when required to be more than 12 inches square, they are to be of stone, the bottom and covering pieces of which must be at least 6 inches longer than the width of the opening.

From the culverts off-take drains are to be cut to the back ditches of the canal or to the wells previously described.

The new portion of the road, as to grade, drainage and in all other respects, must be at least equal to the best part of any of the roads with which it connects.

Any road diversion that is found to be necessary on Section No. 26 must also be formed in like manner as that above described.

The removal of the abutments, guide-piles, down to four feet below the level of the present mitre sill at Port Colborne Lock, also the waling and other timbers at ends and sides of each of the present bridges, together with that of the swing portion of the structure, should all be embraced in one bulk sum for each place, which must include hauling and placing them where pointed out within a distance of 700 feet. All the materials, timber, iron, etc., are to remain the property of the Department of Public Works.

The bulk sum tendered for unwatering the pit for the bridge foundation must embrace the cost of constructing all coffer dams required to keep out the water, and to guard against leakage, springs or surface drainage, together with the expense of pumping, bailing, removing ice and snow and every contingency connected with unwatering the bridge foundation or any other portions of the works during the progress of the operations, and the satisfactory removal of all coffer dams and other temporary structures at or before the usual time of opening spring navigation.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality and all such parts of the structures as may be required will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, &C.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work as contemplated in this specification.

All the materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

The operations must be conducted in such a manner as not to interrupt or impede the passage of vessels or in any way injuriously interfere with the navigation, and subject to the canal regulations now in force, or such others as may be adopted and sanctioned by His Excellency the Governor-General in Council.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract satisfactory security will be required on real estate or by a deposit of money, public or municipal securities or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 1st day of April, 1877.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 17th June, 1875.

APPENDIX No. 18.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTION No. TWENTY-SEVEN of the Enlargement.

This section is about 5,600 feet in length, and includes the principal part of the enlargement of the canal within the boundaries of the Town of Welland, the construction of an aqueduct over the Chippawa River, taking down the greater part of the present lift lock between the river and the canal, building a new lock, removing the abutments of the present road bridge which connects the east and west parts of the Town of Welland, constructing piers and abutments for a new swing bridge farther to the south of opposite what is called Division Street, forming a conduit on the east side of the canal to carry the drainage into the Chippawa River at a point below the present aqueduct, and such other works as are herein described or may be required and which the contractor may be called upon to execute in connection with the contemplated improvements.

The channel-way is to be enlarged to a width of one hundred feet at bottom when sunk to an uniform depth of two feet nine inches below the top of the present mitre sill of the lock at Port Colborne; and the foundations of all permanent structures, such as bridge abutments and piers, aqueduct, etc., are to be placed sufficiently low for a depth of 15 feet in the reach at assumed low-water level of Lake Erie.

The approaches at both ends of the aqueduct and the width of the water-way, where required, must be increased to such dimensions as may be directed when the works are in progress.

The new aqueduct will be placed on the west or up-stream side of the existing one and at a distance of from 75 to 80 feet from it.

The channel-way will for the most part be widened on the west side and the position of the respective structures will generally correspond with the lines shown in red on the general plan exhibited. The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will

admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined; also of altering the position of any or all of the structures one hundred feet or more either to the right or left, or of placing any one or all of them five hundred feet or more either upward or downward from the place indicated on the general plan exhibited, or in such other position as may be considered most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The principal part of the excavation for the widening and deepening of the channel will be clay, but part of it, especially toward the lower end of the section, is of a hard nature, consisting of indurated clay and gravel stone firmly cemented together.

All the side slopes in cuttings as well as those of the banks are to be made two horizontal to one vertical, except where they connect with walls of masonry, when, for such a distance as may be required, they may be made one-half horizontal to one vertical or to any other angle between the least and greatest of these two slopes as may be directed.

The material excavated on the north side of the Chippawa River for the widening and deepening of the canal, the foundation for the north end of the aqueduct and approaches to it, the foundation for the lock and approach to it, or at least all that portion of it in each case that can be done by manual labor in the usual way, must be hauled by carts, waggons or otherwise, and placed in spoil in that portion of the old or original canal on the north-west side of the river, or at such other places in that vicinity as may be directed, within a distance of 1,000 feet from the place where the material has been removed, except what is required for embankment. The balance of the excavation, whether over the water surface or under it, must be hauled, transported and disposed of in the manner subsequently described, at such places on either the east or west bank of the canal as may be directed, within a distance of two miles along the canal either to the south or to the north of where the material has been removed.

The contractor must find the means to transport, handle, elevate and deposit the material at the place or places directed, and at such a distance back from the eastern or western water line of the canal, and in the manner herein described for the spoil banks at other places.

It is, however, to be distinctly understood that, if the material is required to be placed on the east side of the canal, the arrangements for the disposing of it must be such as not in any way or shape to interfere with the free and uninterrupted towage of vessels.

In widening and deepening that part of the channel between the south end of the aqueduct and the south end of the section, the material to be removed, as well as that from the foundations of the piers and abutments of the road bridge and southern part of the aqueduct, can for the most part be placed along the west side of the channel, partly in the original canal, which is to be filled up to the level of the adjoining ground, and the balance of the excavation placed in the manner and at such a distance back from the water line as subsequently described.

TOWING-PATH.—The works throughout must be carried on in such a manner that the present towing-path shall not be in any way interrupted or any part of it interfered with during the season of navigation, unless a new and

convenient trackway be formed at that place, or other approved arrangements be made by the contractor, at his own cost and expense, to enable the towing service along that part of the canal to be satisfactorily performed. It is to be continuous on both sides of the canal except opposite the entrance to the lock and on the east side at both ends of the new aqueduct; where formed in cutting and at places unconnected with structures, its front edge will be 99 feet from the centre line, at 24¾ feet above the bottom of the canal, or 22 feet over the present mitre sill of Port Colborne Lock. It will for the most part be made 15 feet wide on top and have an inclination of about 12 inches outward to a ditch in the rear or at the toe of the slope of the adjoining bank.

The ditch to be at least 3½ feet wide on top and the bottom to have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

It will be observed from the nature of the work that all that portion of it under the water surface connected with the enlargement and deepening of the prism can be done by machinery during the summer months, provided proper precautions are taken to guard against interfering with the navigation. Contractors will therefore be expected and required to provide the necessary equipment for that purpose and be fully prepared to excavate, haul, transport and elevate the material in such a manner as will enable it to be expeditiously removed and deposited at the places above mentioned, unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way in a more expeditious manner within the time agreed upon for its completion.

If any of the adjoining proprietors are desirous of having their land raised to an extent that would render it an object for spoil ground, the contractor, on receiving the sanction of the Department of Public Works, may use part of the excavated material for that purpose.

Spoil Banks—are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut for a foundation for the bank. The new material deposited must be kept back at least ten feet from the top of the bank slope and must not be raised more than ten feet above the level of the towing path, within a distance of 85 feet from the surface water line of the canal on that side on which the spoil bank is formed. Beyond the distance stated the height may be increased after suitable drains and other provisions have been made to carry the surface water to the back ditches.

The spoil banks, as nearly as circumstances will admit, must be made of an uniform height and invariably have a declivity outward of at least one in twenty, and throughout be of a regular width.

Back Ditches—to carry off the surface water and such other natural drainage as it may be necessary to provide for are to be formed at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available.

For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

To form an outlet for the new ditches or present water-courses, other than those specially referred to, wells are to be sunk in connection with them, from which off-take drains or culverts are to be made with such inclinations as will discharge the water freely into the canal two feet or more below the assumed level of Lake Erie.

These wells will be from two to three feet square, and the culverts from them are to be from 15 to 24 inches square. They are to be built of rubble masonry laid in cement mortar; but the bottoms of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least 6 inches under the walls on both sides; the covering of the culverts must also be of flat stones of a length which will bear at least 6 inches on the side walls. The wells and channels from them may, however, be formed of timber and plank, and a bridge be made over the outlet if so directed. In either case the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When conducting the works connected with the widening and deepening of the channel, as well as in placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge.

He must also take great care not to cut into the inside slopes, nor do anything at all likely to have a tendency to impair the stability of the banks.

The bottom of the present channel when deepened, as well as that of the new work, must be made as level and uniform as possible, so as to insure throughout the full width and depth contemplated.

Over water surface the slopes must be trimmed to the angles before mentioned and be made to correspond with the lines marked out on the ground, and agreeably to the instructions of the officer in charge.

EMBANKMENTS.—When the ground on which a bank adjoining the canal or any permanent structure is to be formed is below the water level, the surface must invariably be removed for such a depth as may be required by the nature of the material and circumstances. In all such cases the entire space to be occupied by the bank must be cleared of all sods, turf, muck, loose stones, logs, roots, slabs, saw-dust and all kinds of rubbish or objectionable matter; loose earth or such as will admit of water percolating through it, must also be removed for such a depth as the officer in charge may consider necessary to enable a proper connection with the bottom to be formed.

The seats of all banks must be made nearly level; but where the surface of the ground is such that there is a solid bank between the place of deposit and the channel, part of the seat may have an inclination outward, provided there is within a distance of 100 feet a bank sufficiently solid to prevent the lower part of the embankment or spoil from moving. This must be observed on all parts of the section, but more especially when forming banks at both ends of the new aqueduct and other places in that vicinity, as well as those connected with the new lock, or at any place where a bank has to be formed over sloping ground, otherwise the seat must invariably be either cut down so as to give a level bearing or be made into benches, each of which must of itself present a horizontal surface of sufficient width to admit of a suitable connection being made and so as to guard against any tendency to slide.

For preparing the seats of banks the material removed will be measured in the "solid," and the quantity paid for at the same rate as for earth excavation on that part of the section on which the work is done; this rate should be clearly understood to include the cost of handling all kinds of material necessary to effect the object and the removal of the same to such places within the limits of the section or elsewhere as may be directed.

When forming banks, raising or widening others, or forming embankments adjoining the aqueduct or lock, *or wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time*, and if the work is done at a dry season of the year water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS,—where necessary to be made in any of the banks, must be carried up at the same time the banks are formed. They must consist of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

AQUEDUCT OVER THE CHIPPAWA RIVER.

This structure is to be of dressed gray limestone masonry, laid throughout in hydraulic cement mortar, and will be formed with six archways, any four of which will collectively be of sufficient sectional area to allow the water of the Chippawa River to pass freely; all of them are to be arranged and made of a depth suited to the enlarged scale of navigation as herein described.

It is to be placed in the bed of the river from 75 to 80 feet to the westward of the present aqueduct, and be in other respects so situated that the face of its north abutment shall be four feet to the north of that of the present one, and the range of the south sides of the second pier from the north side in both the old and the new structures shall correspond.

From the face of the north abutment to that on the south side the distance will be 277 feet at the springing line of the arches, and the breadth at the soffit of the arches 112 feet; springing line to be 3 feet over the top of the upper offset in foundation; rise of arches 7 feet, and top of coping of side or parapet walls 28¾ feet over the centre part of the intrados.

As the water of the river must pass at the time the works are in progress, it is contemplated to build the principal part of the new structure in two divisions, but in reality at three different times. This is to be done in order that the coffer dams necessary to enable the work to be laid dry shall, at the time when in use, occupy only a part of the river channel, the width of which is, however, to be increased on the north-west side to such an extent as circumstances will permit or is warranted by the range of the upper part of the stream and the relative positions of the structures.

The dams must, of course, be arranged in such a manner as to occupy the least possible space consistent with their efficiency and with a view to their expeditious removal when no longer required.

The centre line of the new aqueduct will be parallel to that of the existing one, but 171 feet farther to the west, and will in other respects be situated as previously stated, unless for some special reason its position has to be changed, to another fixed point within the limits first mentioned.

EXCAVATION.—The site of the new structure or that part of it for 11½ feet beyond the face of the abutment wall on both sides, or for a length of 300 feet and a distance of 62½ feet on each side of the centre line, or a space of 125 feet, is to be sunk by dredging to the full depth of 41 feet below the top of the coping of the present aqueduct, or to about 23 feet below the medium water level.

The seats for the different piers, after the pit has been laid dry, are to be excavated 4.73 feet lower, or to a depth of 45.73 feet below the point above mentioned (coping of present aqueduct) and the seats of the abutments, or that part of them next the waterways, are to be sunk to 44.23 feet below the bench mark above referred to.

The space between the two structures is to be dredged to the depth of 37 feet below the same point, or to the level of the floor of the present archways; and, for a distance of 65 feet above or on the west side of the new work, the bottom is to be dredged

to the level of 39 feet or more, if required, below the same fixed point, that is to say, the top of the coping on the south-west side immediately over the abutment of the present aqueduct.

In order to give as much space as possible for the flow of the river at the time when the works are in progress, the channel above and adjoining the new structure is to be widened out on the north-west side to the line indicated in red on the general plan exhibited, or for such other width, or to such a depth as may be considered necessary by the Department of Public Works.

The material removed by dredging for the foundation of the aqueduct, the deepening and widening of the channel to the extent above described, or for such other extent as may be required, must be taken up the Chippewa River by the contractor and deposited on ground acquired, at his own cost and expense, at such place or places on the banks as may be approved of by an officer entrusted with that duty.

It will not, however, under any circumstances, be allowed to be deposited in the river, and the place selected on the banks for placing it must be sufficiently solid to carry the additional weight without any risk of sliding or settlement, or in any way having a tendency to diminish the width or depth of the river at or near the place where the spoil bank is formed.

The contractor's arrangements must be such that the material, after it has been taken to the place where it is to be spoiled, can be lifted and thrown back or be otherwise placed at such a distance back from the water line as to leave no doubt whatever but that the river for its full width and depth shall continue to be clear and uninterrupted.

The material excavated from the pit (below the level of 41 feet under the top of the coping of the present aqueduct) after the pit shall have been laid dry, must, of course, be taken out chiefly over the sides of the coffer dams, the cost of which, together with that of finding the necessary spoil ground on which to place it, must be embraced in the price tendered for that item of work.

Coffer Dams—may be constructed by means of two ranges or more of square piles, closely and carefully driven, with a suitable space of not less than 6 feet in width between them for puddled clay. The piles should be at least 13 inches square, sawn or dressed straight and driven by a suitable ram between two horizontal ranges of guide or wale pieces fastened with screw-bolts 1 inch diameter to gauge piles driven not more than 10 feet apart in line of dam. The inside wale pieces to be removed after the piles are driven and before the puddle is put in place. The inside range of sheeting piles must, of course, be supported by means of buttresses or counterforts formed either of piles driven close at right-angles to the dam, or they may be of skeleton framework, the intermediate spaces in either case being strengthened by means of raking and horizontal braces, to guard against unduly straining the dam or any movement under the pressure to which it may be subjected during freshets; the variation between high and low water is fully 6 feet.

The inner and outer rows of piles can at ordinary water surface be connected with cross timbers and at places lower down by means of screw-bolts formed of bars of wrought iron 3½ inches wide by ¾ of an inch thick, forged in such a manner that the part at the ends which passes through the piles will be made round and of a like sectional area as the flat bar; but before one of the ends in each case is interfered with a piece of boiler plate 12 x 15 inches is to be shrunk on to the middle of the bar; both of which (bar and boiler plate) when in the work are to have a vertical position, but at right angles to each other.

These tie-bolts are to have nuts, iron plates and large wooden washers, and should be put in at least 5 or 6 feet below the water surface as the driving of the second course of sheeting piles progresses.

The line of the different sides and ends of the first section of the dam, if constructed chiefly of piles, may be of a circular, elliptic or other form, as may be subsequently determined.

It is believed, from the nature of the material which forms the bottom, that the greater portion of the piles required for a dam of the class above referred to can be driven without being shod with iron, and that one top band will be sufficient for every ten or twelve piles.

The materials used for the puddle must be such that it will settle down generally in a solid mass, and that when in place and beaten down carefully in thin layers it will form, as a whole, a wall sufficiently compact to prevent water passing through it.

The dams are to be built in three different sections and in such a manner as to embrace separate portions of the work, viz. :—

FIRST SECTION—to embrace the space to be occupied by the three southern archways, piers, etc., of the aqueduct.

SECOND SECTION—to include the fourth archway from the south side, together with the piers connected with it, and must be constructed so as to connect with the sides of the *first section* in such a manner as will admit of removing the end of that part of the dam.

THIRD SECTION— embraces the space to be occupied by the two northern archways, and will consist of a separate dam to be formed after the water of the river can be turned through the four southern archways.

The *first section* of the dam may be made to include the space for the oblique line of wall between the south-west abutment of the present structure and that of the new one, otherwise a separate dam may be put in for that purpose ; and when the wall between the two structures has been built, the first section of the main dam can be connected with it by letting the ends of horizontal timbers into checks formed in the face of the masonry for that purpose.

The *second section* is not to be commenced until the works of the three southern arches are well advanced and the spring freshet of the season on which it is to be proceeded with has passed off, when the operations connected with the second section must be urged forward with such a degree of energy that the dam can be built, the north end of the first section removed, the foundation of that part of the structure laid, the walls and arch carried up, as well as all the masonry connected with the three southern arches and side walls over the whole four arches raised to such a height as to be at least over medium water level before the close of building operations that season.

Arrangements are to be made in the end or face of the fourth pier from the south side and walls over it for checks or otherwise, in order that the *third section* of the dam can be properly joined to it.

This latter section may be made to embrace the construction of a dam such as will admit of building a transverse wall between the abutments of the old and new structures, otherwise a separate dam may be formed to enable that part of the work to be done.

It may here be stated that as the dams are solely for the purpose of enabling the foundations to be prepared and the permanent parts of the work to be carried out, they may be constructed in accordance with the general description above given ; otherwise they may be formed by means of crib work for the inside range of the water-tight compartment, and square piles driven close for the outside.

In the event of this course being adopted, the side of the cribs next the puddle chamber must be sheeted with two tiers or courses of boards put on so as to break joints ; they are invariably to be well driven into the bottom and secured to the side of the cribs with the assistance of a diver.

The space between the cribs and outer sheeting piles is to be, of course, filled with the best description of material that can be found in the vicinity, mixed with gravel and otherwise prepared for forming a puddle wall, which, when properly beaten down, will prevent water passing through it.

There would also require to be tie-rods between the outer range of piles and the cribs similar to those referred to in case the dams be formed chiefly of piles.

The alternate compartments of the cribs might only be filled with stone, as a large portion of the necessary weight could be placed on top, and for which purpose large flat stones, required for other parts of the works, might be temporarily used.

In short, the dams necessary for enabling the works to be unwatered may be constructed in either of these ways, or in such other way that they will occupy the least space consistent with the probability of their success, and that they are formed in sections corresponding in extent with those previously mentioned, and that the respective parts in each case are such as will be likely to effect the object herein contemplated in their construction.

Contractors, when tendering for this important part of the undertaking, are expected to state a bulk sum for which they would be willing to construct and maintain each of the three different sections of the dam, including in the *first section* the dam necessary for access to the foundations of the oblique wall at the south end between the abutments of the old aqueduct and the new structures.

In the *third section* is to be included the dam required for access to the foundation of the cross wall between the north abutments of the old and new structures.

The bulk sum tendered for unwatering each of these three different sections of the foundation for the aqueduct must embrace the construction of all necessary coffer dams, the unwatering of that portion of the work, the maintenance of the respective dams, filling up the different spaces within the dams with water and again laying them dry as often as may be found necessary, and keeping the whole or any part of the sections dry as long as may be required by the Department of Public Works for the setting of the mortar or any other purpose connected with the permanent works that may, in the opinion of the officer in charge, be considered necessary.

Contractors should bear in mind when tendering, that, although the works connected with the formation of the dams are to be carried on under the direction of the officers entrusted with the general superintendence of the works, and who will point out the limits within which the dams are to be formed, still the contractor is to be held strictly and legally responsible for their construction, suitableness, stability and maintenance, and for the unwatering of the enclosed space at the time agreed upon and as

often afterwards as it may from any cause be filled either in part or as a whole, and for keeping it unwatered for the full length of time required to execute and complete the permanent works contemplated.

The different amounts tendered for coffer dams and unwatering the works must also embrace the full and complete removal of the respective sections of the dams. This, it is to be clearly understood, is to be done in such a way that for the part of the dams between the old aqueduct and the new structures the puddle walls must invariably be taken out first; and as the piles cannot be allowed to be pulled or drawn out, they must be cut off about the top line of the pitched stone invert of the water-ways of the new aqueduct.

The timber work must in all cases be removed as rapidly as it is loosened, and every precaution taken that may be required to guard fully against obstructing the water-ways of either the old or new structures.

This, the contractor should clearly and distinctly understand, must be done at the time and in the manner he is called upon to do so, whether it be during the winter season, by the employment of divers, or at any other season of the year, or in any other way whatsoever that the Department of Public Works may consider necessary to effect the object.

In case it is found necessary to form a water-tight bulkhead across the trunk of the new aqueduct (at the time the first division of the structure is in progress, or after it has been carried up to the line of high water), either for the purpose of excluding or retaining the water, or to serve both purposes when required, the contractor will be expected to state the bulk sum for which he would construct such a dam or bulkhead, and remove it when no longer required—the difference of level between the crown of the arches and high water in the river being about 11½ feet, and between the same point and low water 5½ feet. The bulkhead is principally intended for medium water or about 8½ feet over the crown of the arches.

When a section of the pit has been unwatered, the bottom is to be sunk to the depth required for a stratum of concrete, which is to form a bearing surface for the masonry of the abutments and piers, as well as for the pitched stone work under the water-ways of the structure.

The bottom under the respective abutments, for a distance of 13 feet parallel to the centre line of the canal and for the whole width to be occupied by the aqueduct and its connecting walls, is to be sunk uniformly to a level surface at $44\frac{23}{100}$ feet below the coping of the present aqueduct. On this a stratum of concrete 2½ feet in depth is to be placed to form a seat for the masonry.

The bottom for each of the piers is to be excavated to the full depth of $45\frac{73}{100}$ feet below the same fixed point on the coping of the present aqueduct, or 2½ feet below the general bottom, for a width of 15½ feet measured along the centre line, except at the second pier from the north abutment, for which the width to be excavated to the depth above stated will be 17½ feet.

The intervening spaces or those under the archways are to be kept 2½ feet higher, or made to an uniform level surface at $43\frac{23}{100}$ feet below the same point on the present aqueduct coping.

At these different levels and for the extent stated at the respective places, that is, the distance on the centre line and width of the structure, its off-sets, cut-waters, etc., the

bottom must be trimmed off to a smooth and uniform surface, and the sides of the cut for the deeper parts made straight and plumb.

The material excavated must in all cases be taken out of the pit, hauled, transported and disposed of either for the purpose of forming embankment, or be spoiled on ground provided by the contractor beyond the line of high water of the river.

If the bottom material continues to be of a like class as indicated by the borings, the abutments and piers of the structure will be placed on a stratum of concrete, and the space under the different arches be of pitched stone laid in cement mortar upon a stratum of concrete. The concrete to be made with hydraulic cement in the manner subsequently described, laid on in layers not exceeding 10 inches in depth, each of which must be well rammed or beaten down. The cut formed for it under the piers and abutments must be entirely filled, and care taken that it is of the full depth—2½ feet—and that the top is brought to a fair level surface for the masonry.

In every case where concrete is used to form a bearing surface, it must be allowed to remain a few days exposed to the action of the atmosphere before it is covered with masonry.

Under the different water-ways the layer of concrete is to be nine inches deep in the centre, increasing toward the sides to about 33 inches, leaving a regular curved surface or invert two feet lower in the middle than at the sides. On this a pitched covering of gray limestone 21 inches in depth, in regular courses of from 5 to 9 inches in thickness is to be laid in full floating beds of hydraulic cement mortar before the centres for arches are placed. The mortar is to be made in the manner and in the proportions subsequently described.

All the stones used for this purpose must be of the full depth (21 inches), and be picked, scabbled or otherwise dressed on all their four sides and ends, so that when in place the joints shall in no case exceed ⅝ (five-eighths) of an inch. The upper surface of each invert must present a moderately fair surface throughout, and the sides of it are to be of a like height as the top of the upper off-set on the lower part of the masonry of the piers and abutments.

On the upper and lower sides of the aqueduct a trench is to be excavated across the river, outside the line of the respective cut-waters, and sunk fully one foot below the bottom of the layer of concrete which forms the seat of the piers. It is to be 2½ feet in width, and in it a wall of concrete is to be carried up to a height corresponding with the surface line of the invert. This wall may be extended from time to time as the dams will permit, but every stretch of it between any two of the piers must be carried up to its full height within three days after it is commenced.

In order to protect the north-west bank of the river when the current is thrown on that side by the coffer dams, a range of sheeting piles, if directed, is to be driven close, on such a line as will be likely to effect that object in the most efficient manner, and be continued until it intersects the western side of the east wall of the old lock. To enable this to be accomplished, the bank will be cut down to low-water line, and gauge piles driven about 10 feet apart, to which guide waling pieces are to be bolted on both sides, to insure, as far as practicable, that the intermediate piles are driven truly.

The whole of them are to be 12 inches square, and of sufficient length when driven to stand at least 2 feet over high-water mark. When they have answered the purpose contemplated, part of them may be cut off to serve as bearing piles and part as sheet-piling for the wing walls.

If found necessary, piles are also to be driven in front of the oblique wall connecting the abutments at the south ends of the aqueducts.

In the event of the bottom material turning out different from what is indicated by the borings, it may be found necessary to drive foundation piles, and otherwise form a suitable bearing surface for the structure in the following manner:

BEARING PILES,—if necessary for the foundation, must be of white oak timber not less than 10 inches diameter at the small end and of such length as may be required by the circumstances. They are to be driven in straight rows over the area to be occupied by the abutments, piers, etc., by a ram weighing not less than 2,000 pounds, falling through a space of at least 30 feet, until the pile does not drive more than one inch at a blow.

They are to be about three feet apart from centre to centre, both cross and longitudinally of the piers and abutments, or such other distance apart as may be subsequently determined.

After they are driven to the full depth required, their tops are to be accurately levelled to receive sills or grillage timbers of white oak 12 inches square. The cross and longitudinal sills must be checked into each other where required and are to be secured to the heads of the piles by means of white oak treenails; their upper surface must be dubbed straight and level to receive the planking, and the spaces between them, as well as between the piles, must be filled with concrete.

The floor under the piers and abutments will be of 4-inch oak plank, secured by $1\frac{1}{2}$-inch oak treenails, and must bear uniformly upon the sills, and a bed of fresh-made cement mortar placed on the concrete.

A course of sheet piles 4 inches thick and 7 feet long will be placed along both sides of each pier, and one along the front and sides of the abutments. They are all to be connected with a range of sheet piles of like dimensions, carried along each side of the aqueduct immediately on the upper and lower sides of the starlings.

The sheet piles must be well jointed and have their outer edges chamfered. When in place, their tops are to be fastened to the sills with 9-inch spikes; those across the water-ways are to be spiked to sill timbers placed there and secured to piles driven for that purpose.

MASONRY.—The stone of which the aqueduct is to be built must be of the best class of approved, sound and durable *gray limestone*, free from seams, drys, shakes, sand holes and all other defects, and generally of the dimensions herein stated. The face stones must be of uniform texture and color, laid in regular courses on their natural beds. In the retaining or side walls of the structure, the courses may vary from 15 to 30 inches in height, but the thickest courses above the crown of the arches must invariably be placed lowest, thence diminish upward in regular succession to the course under the coping. The face work of the abutments, piers, the inside face of the retaining walls and their principal adjoining wings are all to be of boucharded work, and dressed throughout in such a manner that, when laid, neither the horizontal nor the vertical joints will at any place exceed $\frac{3}{10}$ of an inch.

As previously intimated, there are to be six arches, each of 40 feet span and 7 feet rise. It may now be stated that the three at the south end and the northern one, are to be circular segments made to a radius of $32\frac{1}{10}$ feet; about four-fifths of each of the other two arches are to be made to a like radius, but the other one-fifth of them, which

adjoins the fourth pier from the south end, is to be made of a radius of 11¼ feet, and the springing line in both these cases will be 3 feet lower than that of the other arches or that of the opposite sides of the same arches of which they form a part.

It being thus contemplated to build the new structures at three different times, but in such a manner as to be in two divisions—that is to say, to execute the works connected with the four southern arches independently of the two at the north end of the structure.

This unavoidable course renders necessary the adoption of certain precautionary measures, intended to meet the thrust of the fourth or northern arch of the first division.

With a view, in part, of effecting this object, the second pier from the north end is to be two feet wider than any of the others, and part of the two adjoining arches are to be made in some respects elliptical; in addition to which, the third and fourth arches from the south end of the structure are to be connected together by tie-rods in the following manner:

Six tie-rods are to be let in between the two lower courses of footings, to the masonry, of a length to reach from the south side of the third or middle pier to the north side of the fourth or what may be called the abutment pier and the north part of the first division.

These rods are to be arranged in such a manner that three of them will come directly under and within the line of the retaining wall on each side—one being under the centre line of the wall, one two feet from the line of the outer face, and another within two feet of the inner line. They are to be of wrought iron 2½ inches square or of round iron 3 inches diameter, as may be subsequently decided. They may be in two lengths, coupled in an approved manner by means of a suitable connecting bolt passing through a double eye formed on the end of one half, and a single eye made on the other half of the bar.

The outer ends of each bar to be upset, one end slotted for a key and the other end screwed to receive a nut and washer. The joints, keys, thread and nuts must in all cases be fully equal to the strength of the bar.

On the upper side of the first course of masonry over the arches there are to be bars of like dimensions directly over those first mentioned, let in their full depth into the stone. They are to be welded so as to be in one piece, and have eyes formed in them to receive the ends of vertical bars, and are to be made to receive a key at one end and be screwed for a nut at the other. The nuts, keys and weld must in every case have a strength equal to the full section of the bar.

There are also to be vertical bars passing down through the third and fourth piers, and through eyes made for that purpose in both the upper and lower horizontal bars. The lower end of each of these vertical bars is to be screwed into a cast iron plate bedded in the concrete on which the stone work rests, and after passing through the upper bar they are to be screwed down tight before the masonry above them is laid.

If the vertical bars are not placed before the masonry is carried up, the holes made for them in the stones must be loosely filled with wooden plugs to guard against their being obstructed by mortar, etc.

Those stones at the springing of the fifth arch which can be laid before the second section of the coffer dam is removed are to be fastened by straps and dowels in such a

manner as to secure them with a view of getting as much weight as possible on the fourth pier before the centres are struck or slackened.

The stones forming the lower part of the masonry are to be of large dimensions; those for the footings of both abutments and piers must be in courses 18 inches in height, and generally from 16 to 20 square feet area of bed, and in no case less than 12 feet area of bed.

They must invariably be of the full height, and be picked, scabbled or otherwise dressed into regular blocks before being brought on to the work, and such as will lay throughout to horizontal joints not exceeding five-eighths of an inch, and vertical joints of not more than one inch and a quarter.

This, it is to be distinctly understood, applies to the whole of the two footing courses of each of the abutments and to the three footing courses of each of the piers. The full width of the latter (the piers) must in all cases be made up of not more than two and three stones alternately.

For the fourth pier from the south end the footing courses must be 20 inches in height and of still larger dimensions than those above mentioned, as the first or lowest course has a width of 13½ feet, which must in like manner be made up with two and three stones alternately.

The second course of this pier which, for a time, will form an abutment, must be secured to the lower one by vertical bolts or joggles, and the stones be connected with each other by means of dowels of 1¼-inch iron 4 inches long let in horizontally.

The third or upper course of the footings of this (the fourth) pier must be made up of two stones in width, which will be the springing course for the arches on each side and must therefore be formed into a skew-back, all the stones of which are also to be dowelled to each other, and secured to the course underneath with bolts or double joggles in like manner as the second course is to the first one.

All the other piers above the footings must be made up of two stones in width and 16 inches in height, arranged so as to form a bond of at least one foot on alternate sides as well as lengthwise of the pier.

The face of the stones must be dressed to a batter of one in twelve and have their backs scabbled so that the joints between the two ranges of stone shall not exceed one inch.

The upper course in each of the piers is to be formed into a skew-back for the springing of the arches; the nose or thin part of all of these stones must be at least four inches thick, increasing at the required angle.

The width of the pier must be made up of two stones each 3½ feet wide. Their backs must be scabbled, picked or otherwise dressed so that the vertical joint between them shall not exceed one inch, and the course immediately below them must be so arranged that the skew-back will form a bond of at least 12 inches both longitudinally and transversely of the piers.

It is to be observed that the face of the upper footing course of the abutments and piers on the side adjoining the arch must in all cases be bevelled so as to overhang about three inches, and thus form an abutment for the pitched stone invert to be built for the bottom of the water-way.

The arches must be formed in regular unbroken courses of stone the full depth, laid throughout in full mortar beds, to joints not exceeding three-sixteenths ($\frac{3}{16}$) of an inch.

The voussoirs or arch stones must have three feet six inches ($3\frac{1}{2}$ feet) depth of bed at the springing line, gradually diminishing toward the crown or key-stone of the arch, where they are to be not less than two feet eight inches ($2\frac{8}{8}$ feet) in depth of bed.

The whole of them must be headers, that is to say, they must in all cases be of the full depth stated, and when prepared the stone in every range or course must have a mean thickness of not less than 14 inches or more than 21 inches. Their beds must be dressed perfectly smooth and straight and increase truly from the intrados according to the radius of curvature previously stated, namely $32\frac{1}{16}$ feet, except the elliptical portions of the fourth and fifth arches from the south end, which are to have a radius of $11\frac{1}{4}$ feet. For the depth of $2\frac{1}{2}$ feet at the crown, gradually increasing to $3\frac{1}{4}$ feet at the springing line measured from the soffit, their beds must invariably be kept full without depressions, "wants" or other defects, so that when prepared they will present a fair and even bearing surface throughout. They must be in lengths of not less than $2\frac{1}{2}$ feet. At the ends the arrises must be kept good, and the end joints kept full for at least three-fourths of the depth of the stone.

The extrados or backs of the arch stones are to be roughly hammer-dressed to the proper dimensions they should have when in the place they are to occupy.

The intrados or lower side of the arch must be dressed and boucharded, and the beds of the voussoirs, across the whole length of the arch, are to be chamfered to the breadth and depth of one inch.

The heads of the ring stones are to be dressed and project one inch and a half beyond the general line of wall. They are to be jointed to such lines as will admit of forming suitable connections between them and the face stones of the spandrel walls and at the joints they are to be chamfered as stated for the beds of the voussoirs.

The stones in all the different ranges or courses must invariably break joint over and with each other at least 12 inches, and, when being laid, they must be driven up by means of a heavy wooden maul to the joints above stated, three-sixteenths of an inch.

All the end joints must be carefully and fully grouted as the works proceed, and every precaution adopted to make all the joints between the stones in the arches, as a whole, as well as all the works connected with them, sufficiently tight to effectually prevent the escape of water from the canal and guard against it entering from the river.

The starlings or cut-waters at both ends of the piers are to have a projection of $3\frac{1}{2}$ feet; they are to be of a curved, pointed shape from the top of the upper offset to the springing line of the arches, thence their projection and width will gradually diminish until they wholly terminate at a point about $4\frac{1}{2}$ feet higher. Part of each end of the abutment pier is, however, to be carried up to medium high water to form a bearing for the coffer dams.

The arches are to be formed on properly framed centres of sound, moderately well seasoned, suitable timber, and be of approved construction, securely and satisfactorily braced and fitted up. They must be supported on slack blocks such as will admit of their being gradually lowered at least six inches.

Contractors are requested to bear in mind that centres and covering will be required for at least four of the arches at one time, and that the cost of all materials and work-

manship connected with their construction, fitting up and removal, and of fitting up such of them as may be again required, or of others in their stead, must be embraced in the bulk sum tendered for centres, the material in them after use to remain the property of the contractor.

CUT STONE.—The sides of the abutments, the wing-walls on the west side, and walls connecting the present aqueduct with the new structure, are all to be of cut stones with a "rock face," having a chiselled draft of one inch and a half wide around their arrises. They are to be dressed and laid to a batter of one in twelve, or such other batter as may be required, and are to be straight or curved as the position of the wall in which they are to be placed renders necessary.

When dressing the stones their arrises must be kept good, their upper and lower beds made parallel, and the end joints in all cases kept full for at least two-thirds the depth of the beds.

The back parts of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch and a quarter in width.

They are to consist of headers and stretchers, the latter to be at least three feet long in line of wall and not less than two and three feet depth of bed in the alternate courses. In each course there must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than 11 feet from centre to centre.

The headers in each course are to be arranged, as nearly as possible, mid-way between those in the course immediately below.

The faces of the abutments are to be boucharded and must be carried up with a header and stretcher alternately.

No two vertical joints in adjoining courses are to be nearer to each other than 12 inches, and care must be taken that the bond in rear of the face stone is properly formed throughout.

When the face stones are over twenty-four inches in height, the depth of bed of the stretchers in alternate courses must be at least 1½ times their height, and the headers 2¼ times their height, and in all cases the tail of a header must have a width ⅔ the length of its face.

The connecting walls are to be 10 feet thick at bottom, with counterforts 2½ x 5 feet and 10 feet apart; they are to be carried up plumb in the rear to within five feet of the top, where a frost batter will be commenced, and terminate at the top of the coping, which is to be 3½ feet wide. At the ends they are to be bonded into the abutment walls of the present aqueduct, the toothing checks for which are to be included in the price for masonry.

If directed, two checks, each 12 inches wide and 12 inches deep, are to be formed in the face of the south connecting wall.

The wing walls on the west side are each to terminate in a pier at its outer end. The coping upon them is to be 3½ feet wide, from which a frost batter is to increase downward at the rate of four inches each foot for the first five feet, thence the back is to be plumb. The thickness of the wall at the bottom will, however, depend on the height at which a proper foundation can be obtained.

For those parts of the wall above referred to, namely, the abutments, the wing walls on the west side and walls connecting the old and new structures, the backing must consist of large, well-shaped stones, not less than 9 inches in thickness and three square feet area of bed, laid level in full mortar beds and properly bonded throughout the wall. When the depth of the face stone equals or exceeds 18 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face work.

The beds and joints, when necessary, must be scabbled or picked to admit of laying the stones close, and to insure an uniform and equal bearing on the course below and for the course above; no pinning will be permitted. The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

The rear sides of the abutments are to form horizontal, elliptical arches, which at the sides will correspond with the inner line of a continuation of the retaining walls.

The stones of these arches must be of large dimensions, roughly dressed or scabbled, so as to radiate fairly to the curve; this arched form to be continued up to within four feet of the crown of the arches of the water-way; and care must be taken that the hearting of the walls up to that height shall consist of large-sized stones, well jointed and bedded throughout.

RETAINING WALLS.—The side or retaining walls of the structure are to be 13½ feet in width at the bottom line of the canal, and their outer faces, as well as those of the spandrel walls under them, are to be cut stone "rock work," dressed with a chiselled draft one inch and a half wide around the arrises.

The face work of the spandrel walls is to be properly fitted, by checking or otherwise, to the heads of the ring stones; all other parts of these walls up to the crown of the arches are to be of block masonry, prepared and laid as herein subsequently described.

The inner faces of the retaining walls for a stretch of about 427 feet on the east side and 462 feet on the west side are to be of cut stone neatly boucharded on the face, the stones for both outer and inner faces of which must be dressed so as to lay to three-sixteenths of an inch mortar joints and to a batter of one in twenty-four. They are to consist of headers and stretchers, the latter to be two feet six inches (2½ feet) and three feet six inches (3½ feet) depth of bed in alternate courses. In every course there must be headers not less than 2 feet long in line of wall and 5 feet depth of bed.

The stretchers are not to be less than three (3) feet length of face, and headers are not to be more than 6 feet apart in any one course; if a stretcher is 5½ feet in length, which is the longest that will be allowed, there must be a header placed at both ends of it.

All the face stones must be neatly dressed to the batter; those for the inside face are to be carefully boucharded, and the arrises of those for both the outer and inner faces kept good.

To avoid future misunderstanding, contractors are requested to bear in mind when tendering that the beds of all the face stones must be dressed parallel, straight, fair and smooth, and that a stone with depressions in the bed of three-eighths of an inch deep, which in the aggregate exceed one-tenth part of the superficial area of the bed of the stone, will not be allowed in the work. Further, that none of the face stones for the retaining wall will be accepted in which there are depressions in the beds of them one-fourth of an inch deep, within six inches of the face, if such depressions in the aggregate exceed an area of nine square inches.

It should also be clearly and distinctly understood that both the *headers* and *stretchers* must have their end joints kept full and straight—without depressions or "wants"—for at least three-fourths ($\frac{3}{4}$) the depth of the bed of the stone, and that the tail of a header must in all cases have a width of at least three-fourths ($\frac{3}{4}$) the length of its face, and the balance of it must invariably be picked or dressed down at right angles to the bed.

The back parts of all face stones, whether headers or stretchers, must be picked or otherwise dressed off to a line parallel with the face, so that the backing stones, when laid, may form with them joints not exceeding one inch in width.

No two vertical joints in adjoining courses of face stones are to be nearer each other than 12 inches, and care must be taken that at least three-fourths of the whole backing has also 12 inches bond, and the other fourth not less than 9 inches bond.

The courses on the outer and inner faces of the retaining walls must be of the same height for the entire length of the structure, and if they are over 26 inches in height the beds of the stretchers must be of greater width than that above stated.

The course under the coping must be from 16 to 18 inches in height, and on the outer sides of the structure have a projection of eight inches, the lower part of which is to be slightly bevelled off as indicated on plan.

BACKING STONES—for the retaining walls must throughout be picked or otherwise prepared in such a manner that, when laid, they will form what may be termed "block masonry," all the stones of which must be dressed into blocks of a regular shape, and each made of a suitable thickness before they are taken to the place, or at all events before they are allowed to be brought on the work. None of the stones to have less than three feet area of bed, and they should for the most part be of the same thickness as the face work; but occasionally two thicknesses may be used, provided their joint depth does not exceed those in the face.

They must in all cases be prepared, arranged and laid in such a manner that the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints in no case be more than one inch and a quarter ($1\frac{1}{4}$); no pinning, levelling up with spalls or otherwise will in any case be permitted.

COPING STONES.—For the retaining walls the coping stones must be at least eighteen (18) inches in height of course, and not less than four feet long in line of wall. One-third the length of each wall must be made up of stones of such dimensions that two of them will make up the entire width of the top of it, and project eight inches on the outer or face side, and the other two-thirds to be made up of stones of such sizes that three of them will make up the full width and project eight inches on the outer side; that is to say, that four feet in length of each wall must be made up of two stones in width, and eight feet in length be made up of three stones in width alternately, for the entire length of the respective walls.

The lower bed and joints of each stone must be kept full, the upper bed and inner face to be neatly dressed and boucharded, and the inner top arris rounded off to a radius of 3 inches. The whole to be dressed in such a manner that when laid the horizontal and vertical joints shall not exceed three-sixteenths ($\frac{3}{16}$) of an inch.

A dowel 4 inches long of $1\frac{1}{2}$-inch iron must be inserted in every joint, 15 inches back from the inner face and 7 inches below the top line.

After the coping has been laid a hole is to be drilled through the middle of each of the inside pieces nine inches or more into the course underneath and 20 inches back from the face, into which a bolt of 1½-inch iron 18 inches long is to be dropped or driven when hot, and the space over and around it filled with melted sulphur mixed with sand.

The coping stones for the connecting walls and for the west wings are to be 3½ feet wide on top.

It is to be specially borne in mind that before striking the centres of the first divison of the structure, but especially those of the fourth arch, the masonry over the fourth or abutment pier must be carried up as high as circumstances will warrant, particularly those portions of it immediately under the retaining walls, and that every precaution must be adopted to secure the walls at these places, and at the same time have them carried to the height of medium high water at the centre line of the pier, or where the third section of the coffer dam is to connect with them.

The back of the voussoirs between the inside lines of the retaining walls must be scabbled off where necessary, to form fair bearings for the intermediate parts of the spandrel walls where concrete is not used to bring up the spaces between the arches to the proper height.

On the top of the fourth pier the masonry must be carried up to within a few inches of the crown of the arches, and the space on the south side filled in with concrete; loose backing must then be piled up to such a height as may be directed. This backing is to be used in the walls after the fifth and sixth arches have been laid.

The spaces between the arches and the walls carried up on the abutments and piers must be raised to such a height as may be directed, with concrete, and the whole flushed up to a moderately smooth surface with cement mortar of such a depth and in such a manner as may be required.

CONCRETE,—when used in the foundations or elsewhere, must consist of an approved class of stone broken to cubes of 1¼ inches, thoroughly mixed with fresh ground hydraulic cement and clean, sharp sand in such proportions as the materials and works may render necessary. The cement and sand must be reduced to a thin paste before the stones are put into it, and when the whole has been thoroughly incorporated it is to be taken to the place where it is to be used and spread in layers of from 8 to 12 inches in depth and be well beaten down with suitable rammers.

MORTAR.—The whole masonry of the aqueduct and other structures to be herein described must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half (1½) of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand intended to be used for mortar or otherwise, if it is considered necessary by the officer in charge, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stone and back must be well washed if clay or other soil adheres to them, and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The arches must be carried up in such a manner that up to the time of closing them the weight on both sides of the centers for the entire width of the aqueduct must be as nearly as possible equally distributed. The centres are not to be struck or lowered until those parts of the retaining walls within the lines of the first and second sections of the coffer dams or first division and afterwards that part within the range of the third section or second division, have been at the proper time in both cases raised to the height of at least medium high water, or such other height as may be directed.

The outer and inner faces of these walls must, during the progress of the works, be kept at an uniform height, and building operations be conducted in such a manner as not to have more than two unfinished courses at one time within the range of the different sections and so that one wall shall not be raised more than one course higher than the other. The walls of the lift lock are to be carried up in a similar manner as to the relative levels of different parts of the walls.

The stones must in all cases be prepared for the respective places they are to occupy in the work before they are brought on to the walls or any part of the works. They must invariably be laid in full beds of mortar and be driven to their proper bearing by means of a heavy rammer or maul; all the vertical joints of one course must be satisfactorily grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stones must be provided by the contractor, and every precaution adopted to guard against disturbing any of them after they have been laid.

Where the channel of the river is increased in width on the north side above the new aqueduct it may be found necessary to protect the bank from the action of the current to which the northern part of the coffer dam will be likely to give a set in that direction during the period of high water.

This may be done by a line of crib work carried up to near low-water line, then facing the upper part of the bank by a wall of rip-rap or pitched stone, if required by the probable effects of the current.

In case this crib work is required to form a connection between the aqueduct and the lock, it may be found necessary to build a retaining wall on it of the dimensions and class subsequently described.

The embankment on the south side of the structure as well as that on the north-west side of it may also have to be protected with crib work in a similar way to that above mentioned.

In the event of crib work being required at either or all of these places, it may be built of cedar, ash, tamarac, hemlock or elm timber, if straight and of good quality, free from sap-wood, unsound knots or other defects. The sides and ends 11 x 11 inches,

must be double-dovetailed into each other at the angles. and the cross ties will be 10 x 11 inches, dovetailed into the sides; bottoms 9 x 10 inches will be placed six inches apart; the whole secured by vertical binders, and the work throughout done and sunk with stone ballast the usual way for works of that class, and, if used, will be paid for at the respective rates in the tender.

A range of fender piles is to be driven across the river five feet apart at such a distance above the coffer dams for the new aqueduct as will be most likely to protect the works from drift-wood and ice during spring freshets.

If found necessary, a single or double "two-ply" boom must be made and placed above the piles for that purpose, and the contractor must remove all flood-wood at that place from the river as well as break up the ice and keep the channel clear during the progress ot the works at the bulk sum stated in the tender.

Along the outer part of the coping of the retaining wall on either the east or west side of the aqueduct as may be directed, there is to be a plain but substantial wrought iron railing about three feet eight inches high, the posts of which are to be of iron two inches in diameter placed 18 inches apart from centre to centre; every fifth post is to be of iron two inches square with a strut on the inside of a like scantling welded and rivetted to the top of the post.

The foot of all the posts and also that of the struts, are to be let nine inches into the coping stone underneath, and their tops are to be rivetted into a cap-piece three inches wide and one inch and a quarter ($1\frac{1}{4}''$) thick, on the top, of which a flat bar two inches and a half ($2\frac{1}{2}''$) wide by five-eighths of an inch ($\frac{5}{8}''$) thick is to be rivetted.

The work is to be done throughout in a manner similar to that of the railing on the east side of the present aqueduct.

On the top of the retaining wall coping, on the same side of the structure as that on which the railing is placed, a track-way is to be formed of 4-inch white oak plank nine feet long, under which are to be strips of oak scantling three inches wide and one inch and a half thick, one strip at each end and another in the centre; all of which, but not directly opposite to each other, are at every ten feet to be left three inches apart to allow surface water to escape. On each end of the plank an oak cap-piece six by nine inches ($6'' \times 9''$) in length, of at least 20 feet is to be secured with one and three-eighths of an inch ($1\frac{3}{8}''$) bolts placed seven feet apart. The bolts are to pass eight inches into the coping underneath and are to have a nut and screw at the upper end; the nut to be counter-sunk into the caps, and each scarf is to be fastened with two 7-inch pressed spikes.

The bolts of the track-way and the posts of the railing are to be secured with lead, run in around them and well driven down; or they are to be fastened with sulphur and sand as may be directed at the time.

The north-east wing wall of the new aqueduct will connect with the east side wall of the present lock; and such arrangements are to be made that part of this wall will, if possible, form one side of the dividing wall between the old and new structures; otherwise that the division walls shall be built of part of the stone from the old lock, as may be subsequently determined.

The division walls between the old and new structures and their connection with the wing walls at the south-east end of the aqueduct are to be of a heavy class of coursed rubble masonry, that is to say, roughly dressed stone in courses laid either dry or in

cement mortar; or parts of the walls may be laid dry and other parts in mortar, as may be directed as the works proceed.

The extension of the wing walls on the west side of both north and south ends of the new structure are to be of rubble masonry, formed of a large class of sound and durable stones, properly bonded over and with each other; part of these walls are to be in mortar and part laid dry.

The walls at the south end are to be built to such lines as will form a suitable connection between the wing walls, the slope and inner face of the bank. Those at the north are to be made to correspond with the line of the retaining walls, and in both cases the faces of the stones are to be hammered or scabbled to such batter as may be required to adapt them to the position they are to occupy in the work.

COVERED DRAIN.—All that part of the drainage culvert which passes under the canal about midway between Main and Division Streets is to be discontinued, and as much of it removed as may be necessary to afford the required depth of channel for the enlarged scale of navigation. To admit of doing this, a new covered drain is to be constructed on the east side of the canal for a distance of 630 feet or more to a place on the river bank a short distance below the present waste weir.

The drain is to be of masonry laid in hydraulic cement mortar. It is to be 2½ feet wide and 4 feet high inside, and is to be commenced at a level about three feet lower than the present one and continued at such an inclination as may be required to carry off the water efficiently. The bottom of the drain to be of large, flat-bedded stones laid close throughout, not less than 9 inches in thickness, and of such lengths as will give the side walls a bearing on them of at least eight inches.

The side walls are to be 3 feet thick, built of large-sized, flat-bedded stones properly bonded. The covering to be at least 12 inches thick, laid to close joints and have a bearing of not less than ten inches (10″) on each of the side walls, which at the top are to be carried up obliquely to the upper side of the covering, and the whole to be well flushed with mortar.

The excavation for the drain pit being open, the contractor must put a temporary fence along each side of it, and make crossings over the cut wherever required for the public accommodation; and for a like purpose he must put up such a number of lights in lanterns as may be required for safety at night. The cut to be made of sufficient width at bottom for the drain and its side walls; an allowance for a slope of one to one will be made on each side. As soon as 100 feet in length of the cut has been formed the masonry is to be commenced and arrangements must be made for proceeding with the excavation, masonry and filling as expeditiously as possible.

At the lower end or outlet an apron of timber and plank or of pitched stones is to be formed, and a transverse line of sheet piles put in to guard the masonry from being undermined. At two or three places between where the new drain is commenced and its outlet, there are to be transverse lines of sheet piles put in under the bottom and at the rear or the side walls if the declivity is such as to require such a precaution.

The filling must be done in such a manner that the material on both sides shall be well rammed and beaten down; the ramming must be continued for at least 2½ feet over the top of the drain, and as the material settles down the surface must be again made up.

The material excavated that is not again required for filling up the cut must be hauled on an average one thousand feet, to make up the low ground on the east of the

canal south of Division Street; to enable this to be done an addition will be made to the south end of the present drain if required.

The price tendered for the excavation of the drain-pit must embrace filling it up after it is built and hauling the balance of the material as above stated.

ROAD BRIDGE.—This includes the construction of the abutments and piers for a swing bridge, intended as a means of crossing the enlarged canal at Division Street in the Town of Welland.

The water-way at this place is to be in *four* divisions, the two centre ones of which are each to be 46 feet wide and form the navigable channels. The piers and abutments are to be of masonry laid in hydraulic cement mortar, built chiefly in the form, of the dimensions and in the manner herein described or as may be subsequently directed.

In the vicinity of where the bridge piers and abutments are situated a space of 220 feet in length and 170 feet in width is to be sunk to the depth of 4¾ feet below the top of the present mitre sill of Port Colborne Lock, and the sides are to be made to a slope of about one horizontal to one vertical.

The material excavated from this space, as well as from the seats of the piers, which are to be one foot nine inches lower, or 6½ feet below the level of the mitre sills of the lock at Port Colborne, must be hauled to near the upper end of the section and deposited there, as previously described for that from other parts of the excavation south of the aqueduct.

The centre and rest piers of the bridge are to be as nearly as possible parallel to the centre line of the canal, the former to be 18 feet square and the latter 18 feet long by 9 feet thick at top. Through each of them an arched culvert 8 feet in width and about 8 feet in height is to be made on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least six inches under canal bottom, and in each case the piers are, on all sides, to have a batter of one in twenty-four.

The arch-stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom of the arch or water-way, is to be of dressed and properly jointed stones of a size that two of them will make up the width of the opening, and one end of each pass 15 inches under the wall, the second course to project one foot into the opening on each side, and the third course to project inward 6 inches.

The face stones of the piers to be two and three feet depth of bed in alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stone are to be kept full and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface. This is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case to be made up with flat-bedded stones not less than 4 feet area of bed and of the full height of the face stones; their beds and joints must be scabbled or picked if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge when in position are to be 10½ feet thick at bottom, the sides of which are to be parallel in the canal and the ends to be at right angles to the face of the pier. They are to be faced on both sides and throughout be of a like class of material and workmanship, and the foundation for them be formed at a like depth as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty-four.

At four feet from the top of these piers, or at such other height as may be required, off-sets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, the foundations of which are to be laid at 5 feet over canal bottom, or at such other level above or below that point as circumstances may require. They are to be 7½ feet or more in thickness, carried up to a batter of one in twelve on the face to the water line and made plumb in the rear to within four feet of the top, thence the wall will diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers and the backing of large-sized, well-shaped stones laid level in full mortar beds and properly bonded throughout the wall.

The centre pier, piers for seat and rest of bridge as well as the abutments must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable; they must be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top side must have a fair surface, neatly boucharded, and where required the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed; the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones for a width of four feet is to be twenty-four inches in depth and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter let into the masonry underneath.

The coping on the piers for the seat and the abutments for the road bridge will be 10 inches in thickness at the centre of the road, curved on top, so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward, one of which at each end of the bridge must be recessed and hollowed out to receive the machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers and finished with coping as indicated on the plans.

The walls above and below the abutments for a distance of 40 feet or more are to be of masonry, arranged to wind gradually round to meet the line of the slope on the respective sides.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal one foot apart, and for the other piers and abutments they are to be laid either longitudinally or transversely as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete as may be directed.

The covering plank to be of pine three inches thick and must be fastened to the timbers with 1¼-inch white oak treenails eight inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

CRIB WORK.—Between the centre and rest piers, as well as above and below them, and, if directed, above and below the piers for the seat of the bridge, crib work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 18 feet wide at top, increasing downwards on both sides at the rate of one in twenty-four, and through the middle of them, longitudinally, a clear water-way of such dimensions must be formed as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge there are in each case to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of the cribs, the bottom to be of 3-inch plank well fastened with pressed spikes and the top to be formed of pieces not less than 10 inches thick, and the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges and are to be framed so as to leave a space of 1½ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and ⅝ inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed 3½ inches into the timbers under and over them, the dovetail to splay 1½ inches on both sides so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie, in the joint between the courses immediately below it, a block 1½ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt

2½ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them and be secured by bolts of similar dimensions in like manner as described for the transverse ties into which they are to be notched, and fastened at the crossings by means of white oak treenails 2 inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say :—one at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spike $\frac{5}{8}$ of an inch diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from 8 to 10 feet or more, but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than 3 feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay 5 feet or more on the side next the channel.

The whole interior of the crib work except the water-ways to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide piers there are to be two ranges of wale timbers of white oak 6 x 12 inches, the upper range to be fastened by means of screw-bolts ½ an inch diameter having upset heads let into wrought iron washers countersunk for them. The outer range to be 7 feet lower and fastened by rag-bolts ¾ of an inch diameter having similar heads and washers to those in the upper range.

The wale pieces to be put on in lengths of from 24 to 40 feet; their upper edges are to be chamfered and where they connect their ends are to be scarfed, covered with boiler-plate and secured as directed.

For the protection of the structure and piers, three clusters of piles are to be driven within range of the centre pier at suitable distances above and below it; they are to be connected by means of thorough-bolts, straps, etc., and stand 1 foot or more over the cribs, etc., as may be required. Piles are also to be driven for the protection of the crib work, placed above and below the seat piers of the bridge.

In case connected crib work is not placed above and below the seat piers of the bridge, the sides, if directed by the Department of Public Works, are to be protected in the following manner :—

FENDERS—are to be constructed on the land sides of both the water-ways, extending for some distance above and below the bridge as represented on the general plan. They are to be formed by means of piles, caps, anchor timbers and wale pieces, all of white oak timber. The piles to be not less than 11 inches diameter at the

small end, driven from 6 to 10 feet into the bottom, three in a group, at about 12 feet from centre to centre, and one at the middle of each anchor timber when they exceed 25 feet in length. The caps are to be formed of two pieces, each 6 x 10 inches, arranged about 8 inches apart and checked obliquely to receive a dovetail formed on the head of the piles, to each of which they will be secured with wrought iron screw-bolts $\frac{7}{8}$ of an inch diameter having upset heads and cast iron bevel washers let flush into the outside cap-pieces.

Immediately under the caps the anchor timbers will connect with a dovetail the outer piles and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter; they will bear on the inside pile of the group and the ends extend to the outside of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same or inside piles with a screw-bolt of one and one-eighth ($1\frac{1}{8}$) inch round iron, having upset heads and washers, sunk flush as described for the cap-pieces. Where the wale-pieces are scarfed they must be secured to the outer piles with screw-bolts $\frac{7}{8}$ of an inch diameter, with nuts, heads, etc., as described for the others. At seven (7) feet below the top of the cap-pieces, another range of waling 8 x 10 inches is to be put on and fastened throughout with bolts, in like manner as for the upper tier.

The outer ends of the anchor timbers must be let into the banks for such a distance as may be required, and be secured to mud sills or cross timbers.

The superstructure of the bridge—both for the fixed and movable parts—as well as the machinery for working the latter, will be made a separate contract.

Parties "tendering" should bear in mind that all the works connected with the construction of the piers and abutments of this bridge must be done between the close of navigation of the present year (1877) and the opening of the canal in the spring of 1878; or during the winter in which the water of the summit level of the canal is drawn down as low as possible for these and other purposes.

For the distance previously stated—220 feet—at the place where the bridge works are situated, the excavation required to be done below the surface water line for the widening and deepening, preparing foundations of pier, abutments, etc., will be measured, estimated and paid for as bridge pit excavation.

The bulk sum tendered for unwatering the pit for the bridge foundation must embrace the cost of constructing all coffer dams required to keep out the water and to guard against leakage, springs or surface drainage, together with the expense of pumping, baling, removing ice and snow and every contingency connected with unwatering the bridge foundation or any other portions of the works during the progress of the operations, and the satisfactory removal of all coffer dams and other temporary structures at or before the usual time of opening spring navigation.

From the line of the present bridge to Division Street, a macadamized road is to be formed on the east side of the canal, of such a width, height and grade as property in the vicinity and circumstances will permit.

On the west side of the new bridge a road is also to be made across the canal property. In both cases the road must be made up with material from the canal excavation; that on the east side is to have a covering 12 inches in depth of an approved class of broken stone, the first six inches in depth to consist of stone broken to cubes of about four inches, and the upper six inches must be broken to such dimensions that every piece in its greatest length could pass through a ring two inches in diameter. The macadam-

izing to be properly shouldered up and side ditches formed on one or both sides of such dimensions and with such bottom inclination as may be required for efficient drainage.

The present swing bridge is to remain undisturbed until the new structure is in full working order, when the whole of the old bridge is to be removed and everything done to clear out the channel to the required capacity.

Contractors are therefore reminded that this work will have to be done at a time when the water in the canal is at its usual height, that is to say, both the masonry of the abutments and the fender cribs will have to be taken out by means of a dredge or other machinery, and are therefore to be tendered for by the cubic yard; the rate or price to include the full removal of all mason work of the abutments, the fender cribs, their filling, etc, hauling and depositing the same at such places, within a distance of one thousand feet or more, as may be pointed out, or placing them on spoil ground provided by and at the expense of the contractor.

The removal of the swing or movable part of the structure, together with the rollers, segments and all the wrought and cast iron connected with it; the waling and all such timbers as do not come under the first head, (or rate per cubic yard), are to be embraced in the bulk sum tendered for the removal of the swing bridge, etc., all of which are to remain the property of the Department of Public Works, and must be hauled to and placed on canal property where pointed out, within a distance of two miles.

The wharves on the west side of the canal, south of the present swing bridge, have to be removed; the piles drawn or dug out, and the entire material of which they are built, hauled and placed beyond the limits of canal property, all the cost and expenses, directly or indirectly connected with which, must be included in the bulk sum tendered for that purpose.

The present lift lock between the Chippawa River and the canal having to be removed it is intended that a new lock, if constructed in its stead, will be of like dimensions as the present structure, and placed on either the south or north side of the river as may be subsequently determined.

The class of workmanship of the contemplated lock being in either case the same; the connecting walls, although differing in extent, are also of a like class; and the river connection as well as the protection works being, in general similar, contractors are therefore informed that the tenders submitted by them for the works must be prepared in such a manner that the rates stated are clearly and distinctly understood as *the rates* which are to be applied throughout to the respective items of work, whether the lock be built on the south or on the north side of the river.

If placed on the north side of the river, the lock will be so situated that the face line of the north abutment of the new aqueduct when produced will pass transversely through about the middle of it, and the centre line through it longitudinally will be such that opposite the lower gates it will be 245 feet from the west side of the aqueduct, and opposite the upper gates the centre will be 230 feet distant from the same line.

A small circular basin will be formed above the lock, which will connect with the enlarged canal by a channel through the west towing path.

Between the aqueduct and the tail of the lock a range of crib work will be placed along the new margin of the river, over which will be a wall of heavy random-coursed masonry, raised to the height of the lock wall at one end and to that of the aqueduct at the other end, and made either lower in the middle or carried up a like height throughout.

If the lock is placed on the south side of the river, the longitudinal centre line through it will have an inclination of 15 degrees to the north of a right angle to the range of the aqueduct, and 240 feet south of the face of its south abutment. The upper wings will be extended so as to form a passage way through the towing path, and the south bank of the river will require to be protected by means of crib work and a wall, as stated for that on the *north side.*

The Department of Public Works reserves to itself the right of adopting either of these places for the contemplated lock, and, in either case, of changing the site or position to such an extent or distance as may be considered most advantageous for effecting the object.

These changes, it should be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work, and at which rates only the actual quantities of work done will, under any circumstances, be paid.

LOCK—to be one hundred and fifty (150) feet in length between the gate quoins; twenty-six and a half ($26\frac{1}{2}$) feet wide in the clear; the bottom to be sunk and arranged in such a manner that the top of the mitre sills shall be nine and a quarter ($9\frac{1}{4}$) feet below the low-water line of the Chippawa River.

The side walls are to be of masonry, laid throughout in hydraulic cement mortar, and carried up to the same level as the walls of the aqueduct; the whole of the work to be of the class and executed in the manner hereinafter described.

EXCAVATION.—The pit for the foundation of the structure to be made two hundred and thirty feet in length and, for the chamber part, fifty-three feet in width; for the recesses and wings the width will be about fifty-five feet; the whole to correspond to such lines as marked out by the officer in charge, and be made to such slopes as may be required for the stability of the banks during the building operations.

The bottom must throughout be trimmed fair, smooth and level at the depth of eleven and a quarter feet below the low-water line of the Chippawa River, or to such other level as will give an uniform bearing to the foundation timbers on which the walls are to rest.

From the head of the lock to where the entrance channel connects with the line of the main canal the bottom is to be sunk twenty feet lower than the level of the aqueduct coping, and the water-way made of the width required by the circumstances, together with a sufficient space for the side walls to be built alongside of it.

From the tail of the lock to the river the channel is to be made thirty feet wide at bottom when sunk to the depth of one foot below the mitre sill of the lock.

The material excavated from the lock pit and entrance channel, when of a suitable kind, is to be used for embankment, and such of it as may be considered by the officer in charge to be unfit for that purpose or found not to be required for it, must be removed and disposed of as stated in a preceding part of this specification.

All the excavation taken from the channel below the lock must be hauled, transported and placed in spoil on ground provided by and at the expense of the contractor, as mentioned for the material taken from the foundation of the aqueduct.

The seats for all banks must also be prepared by mucking and removing unsuitable material as previously described, and the rate tendered for excavation must cover the cost

of making up banks in rear of lock walls and at any other place where they are required within the limits of the section.

FOUNDATION TIMBERS—to be of pine 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill and at the lower end of the lock, and must rest uniformly throughout their entire length on the bottom and on sub sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle well cut and rammed, or, if directed, the spaces and at the ends of the timbers must be made up with concrete; their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers before being laid must be counterhewn if so directed.

SUB SILLS.—Two ranges of sub sills are to be placed longitudinally under each of the side walls. They are to be of pine timber 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle or concrete as may be required.

MITRE SILL PLATFORM—to be 10 feet in width, made up of timbers 12 inches square and of a length to reach from rear to rear of walls, all of which must be counterhewn and well jointed with a plane so as to make water-tight joints for their entire length and depth. They are to be secured by three wrought iron screw-bolts $1\frac{1}{2}$ inches in diameter passing horizontally through the platform.

Both ends of the bolt must have double nuts and washers in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, ETC.—Five or more trenches are to be cut across the foundation for the reception of sheet piles, namely: one at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built or anchor timbers arranged and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best material for that purpose which can be obtained on the section, and must be cut, mixed, prepared and laid as directed by the officer in charge. Ranges of sheet piles are also to be placed in the foundation of the chamber if so directed.

SHEET PILES—to be of 4-inch pine plank placed close vertically, generally 6 feet long; they are to be jointed with a plane and the edge of each plank

chamfered on the side next the trench. When placed they are to be fastened to the platform or sill timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking in both courses must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid, the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be $32\frac{1}{2}$ feet long, let 3 feet into the wall at each end; they, as well as the braces, must be of a size to stand 18 × 15 inches when dressed. The mitre sills are to be 18 × 18 inches, checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep is to be cut into the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas well saturated in boiling tar is to be placed in the check formed in the platform into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet three inches long, one inch and a half ($1\frac{1}{2}$in.) diameter, have upset heads, and be well ragged at the points.

MASONRY.—The side walls of the lock are to be about thirty one feet in height; those forming the chamber are to be ten and a half ($10\frac{1}{2}$) feet thick at bottom, strengthened by counterforts, with two and a half ($2\frac{1}{2}$) feet projection and six (6) feet in length carried up in rear, not more than twelve feet apart in line of wall; the recesses are to be twenty six inches deep and the walls of them eleven (11) feet thick at bottom.

The faces of the quoin piers, recesses and wings are to be carried up plumb, but the chamber walls are to have a batter of one in twenty four.

The backs of the walls are in all cases to be carried up plumb to within five feet of the top, thence batter to the rear line of the coping; counterforts to terminate where the frost batter on other parts of the walls commence.

All the masonry of the new lock must be of an approved class of sound and durable stones, those which form the face work must be free from drys, seams or other defects, and must be at least equal in every respect to the best class of stones used in the walls of the present lock.

The piers at the gate quoins, the recess piers and the coping are all to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths ($\frac{3}{16}$) of an inch.

The chamber walls, recess walls and wings are to be faced with a good description of neatly-picked or pointed coursed work—coping excepted—prepared in such a manner that when laid their beds end and joints shall not exceed one-half ($\frac{1}{2}$) an inch.

The north-west wall and a large part of the lower and upper ends of the south-east wall of the present lock must be taken down and removed to at least twenty one feet below the level of the coping of the aqueduct, or to the floor of the lock, if so directed.

All the stones thus removed that may be found suitable for use in the new structure must be placed in such positions that they can be advantageously used for that purpose or for the retaining wall, as the contractor may be directed.

The defective portions of the stones and waste to be spoiled beyond the limits of the section, on ground provided by the contractor, or at such a place that they will not interfere with any of the contemplated improvements.

The contractor to state in the tender the rate per cubic yard at which he will be willing to remove the whole of the old lock, or any part of it he may be called upon to take down at any time during the progress of the works on the section.

He will also be expected to state in the tender a bulk sum for which he will be willing to form a dam above the present lock and another below it. The upper dam to be built in such a manner as will be certain to meet the requirements when the water of the main canal is at its highest level—the lower dam to be so constructed and of such a height as will admit of laying the bottom of the lock dry.

In this bulk sum must also be included all the pumping necessary for unwatering the space between the dams down to the floor of the lock, if required.

The stones taken out of the old lock which may be considered fit for use and be allowed in the new lock will be charged to the contractor at the following rates :—

Hollow quoins,	per cubic yard.....	$7 50
Coping stones,	"	6 50
Recess quoins,	"	6 00
Cut stone ashlar,	"	5 50
Chamber and other face work,	"	4 00
Backing stone,	"	2 50

The stones, other than those referred to, must be of the dimensions herein stated, and be prepared in the following manner :—

CUT STONES—must be neatly dressed, boucharded and suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel and their end joints in all cases kept full for at least two-thirds the depth of the beds.

The backs of the stones must be hammered or picked to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

They are to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than 2 and 3 feet depth of bed in the alternate courses. In

each course must be headers of at least 2 feet length of face and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible, mid-way between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least ½ times their height, and the headers 2¼ times their height; and in all cases the tail of a header must have a width of two-thirds (⅔) the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former three and a half (3½) feet face and five (5) feet depth of bed, the latter five (5) feet face and three and a half (3½) feet bed. The headers are to be checked so as to bond at least 1 foot over the face stones of the recess. The nose of the quoins to be rounded and the hollow adapted to quoin-posts of 16 inches diameter and otherwise prepared in a manner similar to those in the present lock.

RECESS QUOINS—to be also 3½ x 5 feet and 5 x 3½ feet, laid alternately out-bond and in-bond, the outer corner to be chamfered to 6 inches deep on the face and 8 inches in the recess; the headers to be checked so as to make return-bond with the face-stones of the recess.

The ends of the stones which form part of the chamber quoin and recess piers are to be bevelled off, and made to form a bond at the inner angle and a foot over it alternately.

COURSED WORK,—for the face of the chamber, recesses and wing-walls may be 9 inches high and upwards, but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone.

They must be at least 18 and 28 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 3½ feet depth of bed, placed not more than 12 feet apart from centre to centre.

The face of the stones must be neatly picked, pointed or scabbled to suit the batter of the chamber; for other places the beds are to be at right angles to the face, and in all cases they must be made to such lines as will adapt them fully to the position they are to occupy in the work. Their end joints must be squared or kept full for a distance of at least 6 inches back from the face, and all prominent or projecting points must be dressed off both beds of the stone of every course, and everything done that is necessary to guard against the horizontal or vertical joints exceeding half (½) an inch.

BACKING.—For 10 feet below and 4 feet above the gate quoins the backing must be of an approved class of large well-shaped stones not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall.

The lower beds, if necessary, must be picked off so as to give a fair and equal bearing on the course below; thin wedge-shaped edges of stone must in all cases be broken off to not less than 6 inches thick.

The backing stones must invariably be laid on their broadest beds. No pinning will be permitted.

The backing for the chamber work must also be of flat-bedded stones, but they may be of less dimensions than those above described, provided they have a bond of 9 inches, and that the bond in the interior of the wall is at no place less than 6 inches.

All the stones must be laid in full mortar beds, and the vertical joints be fully grouted up as the work proceeds.

COPING STONES—of the chamber, recesses and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and those for the chamber to the face-batter of the walls. They are to be of a like height of course as those on the present lock, and not less than 4 feet long in line of wall.

The coping at the hollow and recess quoins must be, however, $6\frac{1}{2}$ feet square on top.

The lower beds and joints of each stone must be kept full; the upper beds and faces neatly dressed, and the inner top arris rounded to a radius of 3 inches. If directed, a dowel 4 inches long of $1\frac{1}{2}$-inch iron is to be inserted in every joint 15 inches back from the face and 6 inches from the top.

BREAST WALL—to be carried up to within 6 inches of the bottom of the adjoining reach, unconnected with the side walls of the lock. It is to be of coursed masonry, 7 feet wide at bottom, plumb in the rear, and on the lower side batter to a width of 4 feet on top; it is to be covered with large, flat-bedded, scabbled and well-jointed coping stones.

MORTAR AND GROUT—to be prepared and used as previously described, and the works generally carried on as stated in the preceding part of this specification.

Contractors are expected to state a price in their tender for which they would be willing to protect the entrance channel from the canal to the lock in each of the following ways, viz:

1.—By a wall of random-coursed masonry—that is to say, that both beds of the face stones are to be level, but continuous courses will not be required. The walls to be $2\frac{1}{2}$ feet wide on top and have a batter of *one-sixth to one* on the front side, and on the rear side increase at the rate of *one-fourth to one* for the first 4 feet from the top, thence downward they are to be plumb.

The walls must be built of an approved class of sound, durable, flat and well-shaped stones, not less than 6 inches thick and 2 feet in length, with at least 3 feet area of bed, laid so as to form proper bond over and with each other in both front and rear. The faces of the stones must be hammered or scabbled to lines corresponding to the position they are to occupy in the work, and in every 15 inches in height of wall there must be headers of at least 3 feet depth of bed, placed not more than 7 feet apart.

The coping stones must be $2\frac{1}{2}$ feet wide, not less than 3 feet long, and at least 9 inches thick.

In rear of each wall, from a line 15 feet below the top, a space 15 inches in width is to be made up with small stones or quarry waste, well rammed.

The retaining wall between the aqueduct and the lock to be of a similar class of work.

2.—Making the inclination of the bank two-thirds horizontal to one vertical and facing it with pitched stone 3 feet in depth at bottom and 2½ at top. The stones to be laid on a foot in depth of quarry refuse or gravel and at right angles to the face, in regular courses six inches or more in thickness; one-third of the superficial area to be of stones the full depth of bed above stated, the other two-thirds may be made up of two stones.

The rear part of the first or lowest course to be let into the bottom, and the top course throughout to be 2½ feet in width and 9 inches thick, made with a rounded edge, if so directed.

The stones must in all cases bond properly over and with each other, and the whole be executed in a satisfactory and workmanlike manner.

It is to be distinctly understood that the tender for either the vertical wall or inclined protection wall may be accepted as a whole or in part, without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

It is also to be clearly and distinctly understood that all the excavation, dredging or work to be done on this section for the deepening and enlarging of the canal, for the foundation of the aqueduct, increasing the width of the channel of the Chippawa River, and forming entrances to the lift lock, etc., will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those parts of the ground to be removed over the water surface and accurate soundings made, with reference to fixed and permanent bench marks, at short distances apart along the whole length and breadth of that part of the present canal within the boundaries of the section; also of that part of the Chippawa River where the aqueduct and other works are to be placed and where the river is to be widened.

Contractors intending to tender for this work are requested to bear in mind that none of the material excavated for the enlargement or deepening of the canal will be allowed to pass down through what is called the aqueduct lock; nor will any of the material excavated from the bed of the river, the foundation of the aqueduct, the widening or deepening of the river channel, forming an entrance to the lift lock, or for any other purpose whatsoever, be allowed to be taken up through that lock.

In all matters connected with the prosecution of the works, the transportation and delivery of all materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel when passing through the canal may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed drawings, arranged, modified and adapted to the circumstances and the locality, and for all such parts of the structures as may be considered necessary for the full understanding of the design will be furnished as the works proceed.

If any alterations be rendered necessary by any cause or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attachrd the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required, by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in order following:—

The covered drain on the east side of the canal to be completed by the 15th day of November next (1877).

Dredging operations for the foundation of *First* and *Second* Sections of the new aqueduct to be proceeded with for at least two months during the autumn of 1877.

Material to be provided and delivered by the 15th day of November next, for the masonry, pier work, etc., for the road bridge opposite Division Street, in the Town of Welland.

The piers, abutments and protection works for this bridge to be built between the closing of the canal this autumn and the opening of navigation in the spring of the year 1878.

Coffer dams for the main parts of the *First* Section of the new aqueduct to be put in during the winter and spring of the year 1880.

In the summer and autumn of the year 1878 the space within the *First* Section of the coffer dams for the aqueduct to be unwatered, excavated to the required depth, the foundation laid and part of the masonry built.

In the year 1879 the coffer dams for the *Second* Section of the aqueduct to be put in, the foundation laid and the masonry of the four southern arches carried up to at least medium high water.

The new lift lock to connect the Chippawa River and canal, in the Town of Welland, to be completed by the first day of September, 1879.

In the winter of 1879 and 1880 the coffer dams for the *Third* Section of the aqueduct to be put in, the foundation laid and masonry carried up in the summer and autumn of the year 1880.

Further, the entire arrangements must be such as will fully satisfy the Department of Public Works that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the first day of June, 1881.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 20th June, 1877.

APPENDIX No. 19.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTION No. TWENTY-EIGHT of the Enlargement.

This section extends from a point nearly opposite the place where the line of the original canal takes a sudden bend to the south-east at about mid-way between the present road bridge over the canal at the Town of Welland and the bridge for the crossing of the Canada Southern Railway; it continues fully 1,500 feet to the south of a line passing longitudinally through the centre of the lock at the Junction, and is in the aggregate about 4,950 feet in length.

The works upon it embrace the widening and deepening of the canal and depositing the material excavated at the places and in the manner herein stated; the construction of the piers and abutments for a swing bridge at the Junction; the removal of the abutments, piles, fenders and all other parts of the present swing bridge necessary to give the full width of channel and slope to the banks, including the removal of the bridge itself, and such other works as may be required to effect the contemplated object.

The water-way is to be enlarged to a width of one hundred feet at bottom when sunk to an uniform depth of 12¾ feet below the top of the mitre sills of the present lock at Port Colborne, and the foundations of the bridge abutments and piers are to be placed sufficiently low to afford a depth of 15 feet in the reach at assumed low-water level of Lake Erie.

The excavation connected with the increased width of channel will, for the most part, be on the west side of the present line; the site of the new bridge will be immediately south of where the feeder connects with the main canal, which, together with the width of water-way at the different places, is indicated in red on the general plan.

The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may

be subsequently determined; also of changing the position of the road bridge to any place between the line of the Canada Southern Railway and the south end of the section that may be considered the most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The side slopes in cuttings as well as those of banks are to be made two horizontal to one vertical, except where they connect with the bridge abutments, when, for such a distance as may be required, they may be made one-half horizontal to one vertical, or to any other angle between the least and greatest of these two slopes as may be directed.

For about 200 feet at the north end of the section and 850 feet at the south end, and in the vicinity of the Canada Southern Railway, the west bank or towing path will pass through the original canal; these places must be made up during the time when the water is drawn off. Contractors are therefore requested to bear this in mind, as well as the fact that these parts of the bank must be made of material excavated inside the line of the enlargement, that is to say, of such material as now forms the west bank of the present canal at any place within a distance of 1,200 feet of where it is to be used, if required. The seats for them must be made either level or with a declivity outwards from the canal, in steps of not less than 15 feet in width, transversely; at all places the seat for them must be cleared of all muck, loose stones, logs, roots, slabs and all kinds of rubbish and objectionable matter; loose earth must also be removed for such a depth as the officer in charge may consider necessary.

In all cases where a bank adjoining the canal has to be made over sloping ground the seat must invariably be either cut down so as to give a level bearing or be made into benches, each of which must of itself present a horizontal surface of sufficient width to admit of a suitable connection being made and so as to guard against any tendency to slide.

For preparing the seats of banks the material removed will be measured in the "solid," and the quantity paid for at the same rate as for earth excavation on the section, which rate should be clearly understood to include the cost of handling all kinds of material necessary to effect the object, and the removal of the same to such places within the limits of the section or elsewhere as may be directed.

When forming banks adjoining the canal *the material must be hauled on to the respective places in carts or waggons and laid on in layers not exceeding one foot in depth at a time.*

The material excavated in widening and deepening the channel, for fully half a mile at the north end of the section, can be placed on the west side of the canal at the distance back from the water line, and in the manner subsequently stated.

On the south side of the Canada Southern Railway there is a large area of water-covered space which can be used for spoil ground to such an extent as the contractor's arrangements will admit, provided the material is kept sufficiently back from the line of the canal and placed as herein described.

All other parts of the excavated material must be placed toward the upper end of the section, or, if necessary to obtain space, one thousand feet or more to the southward of it, except what is required to form, on both sides of the canal, suitable approaches to the swing bridge.

TOWING PATH.—The works throughout must be carried on in such a manner that the present towing path shall not be in any way interrupted, or any part of it interfered with during the season of navigation, unless a new and convenient trackway be formed at that place, or other approved arrangements be made by the contractor, at his own cost and expense, to enable the towing service along that part of the canal to be satisfactorily performed. It is to be continuous on both sides of the canal, except opposite the entrance to the Junction lock and feeder; where formed in cutting and at places unconnected with structures, its front edge will be 99 feet from the centre line at 24½ feet above the bottom of the canal, or 22 feet over the present mitre sill of Port Colborne Lock. It will for the most part be made 15 feet wide on top, and have an inclination of about 12 inches outward to a ditch in the rear or at the toe of the slope of the adjoining bank.

The ditch to be at least four feet wide on top and the bottom to have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

It will be observed from the nature of the work that the greater portion of it under the water surface, connected with the enlargement and deepening of the prism, can be done by machinery during the summer months, provided proper precautions are taken to guard against interfering with the navigation. Contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be fully prepared to excavate, haul, transport and elevate the material in such a manner as will enable it to be expeditiously removed and deposited at the places above mentioned, unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way in a more expeditious manner within the time agreed upon for its completion.

SPOIL BANKS—are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut for a foundation for the bank. The new material deposited must be kept back at least ten feet from the top edge of the slope of the old bank, and must not be raised more than ten feet above the level of the towing path, within a distance of 85 feet from the surface water line of the canal on that side on which the spoil bank is formed. Beyond the distance stated the height may be increased after suitable drains and other provisions have been made to carry the surface water to the back ditches.

The spoil banks, as nearly as circumstances will admit, must be made of an uniform height, and invariably have a declivity outward of at least one in twenty, and throughout be of a regular width.

BACK DITCHES,—to carry off the surface water and such other natural drainage as it may be necessary to provide for, are to be formed at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available. For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

To form an outlet for the new ditches or present water-courses, other than those specially referred to, wells are to be sunk in connection with them, from which off-take drains or culverts are to be made with such inclinations as will discharge the water freely into the canal two feet or more below the assumed level of Lake Erie.

These wells will be from two to three feet square, and the culverts from them are to be from 15 to 24 inches square. They are to be built of rubble masonry laid in cement

mortar; but the bottoms of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least 6 inches under the walls on both sides, the covering of the culverts must also be of flat stones of a length which will bear at least six inches on the side walls. The wells and channels from them may, however, be formed of timber and plank, and a bridge be made over the outlet, if so directed. In either case the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When conducting the works connected with the widening and deepening of the channel, as well as in placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge.

He must also take great care not to cut into the inside slopes nor do anything at all likely to have a tendency to impair the stability of the banks.

The bottom of the present channel when deepened, as well as that of the new work, must be made as level and uniform as possible, so as to insure throughout the full width and depth contemplated.

Over water surface the slopes must be trimmed to the angles before mentioned, and be made to correspond with the lines marked out on the ground, and agreeably to the instructions of the officer in charge.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal, excavation for bridge, etc., etc., will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those portions of the ground to be removed over the water surface, and accurate soundings made, with reference to fixed and permanent bench-marks, at short distances apart, along the whole length and breadth of the section. A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Public Works, and another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

ROAD BRIDGE.—This includes the construction of the abutments and piers for a swing bridge, intended as a means of crossing the enlarged canal at a point immediately south of where the Feeder connects with the main line.

The water-way at this place is to be in four divisions, the two centre ones of which are each to be 46 feet wide, and form the navigable channels. The piers and abutments are to be of masonry laid in hydraulic cement mortar, built chiefly in the form, of the dimensions and in the manner herein described, or as may be subsequently directed.

In the vicinity of where the bridge piers and abutments are situated, a space of 220 feet in length and 170 feet in width, is to be sunk to the depth of $4\frac{3}{4}$ feet below the top of the present mitre sill of Port Colborne Lock, and the sides are to be made to a slope of about one horizontal to one vertical.

The material excavated from this space, as well as from the seats of the piers, which are to be one foot nine inches ($1\frac{3}{4}''$) lower, or $6\frac{1}{2}$ feet below the level of the mitre sills of the lock at Port Colborne, must be hauled to near the upper end of the section and deposited there as previously stated for that removed at the southern part of the work. This work will be measured, estimated and paid for as bridge pit excavation.

The centre and rest piers of the bridge are to be as nearly as possible parallel to the centre line of the canal, the former to be 16 feet square and the latter 16 feet in width and 9 feet thick at top. Through each of them an arched culvert 6 feet wide and 8 feet in height is to be made on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least six inches under canal bottom, and in each case they are to have a batter of one in twenty four.

The arch stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth ($\frac{1}{4}$) of an inch. The bottom part of the arch or water-way is to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening and the end of each pass 15 inches under the wall, the second course to project one foot into the opening on each side, and the third to project inward 6 inches.

The face stones of the piers to be two and three feet depth of bed in alternate courses, with headers in every course $4\frac{1}{2}$ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stone are to be kept full and dressed so as to lay to joints one-fourth ($\frac{1}{4}$) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case to be made up with flat-bedded stones not less than 4 feet area of bed and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge when in position are to be $10\frac{1}{2}$ feet thick at bottom, the sides of which are to be parallel in the canal, and the ends to be at right angles to the face of the pier. They are to be faced on both sides, and throughout be of a like class of material and workmanship, and the foundation for them be formed at a like depth as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty four.

At four feet from the top of these piers, or at such other height as may be required, offsets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, the foundations of which are to be laid at 5 feet over canal bottom or at such other level above or below that point as circumstances may require. They are to be $7\frac{1}{2}$ feet or more in thickness, carried up to a batter of one in twelve on the face to the water line, and made plumb in the rear to within four feet of the top, thence the wall will diminish to the rear line of the coping, which will be $3\frac{1}{2}$ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized well-shaped stones laid level in full mortar beds and properly bonded throughout the wall.

The centre pier, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout and have all the vertical joints well grouted as the work proceeds.

Coping-stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge and

break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch ; and the top side must have a fair surface, neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers one of the coping stones for a width of four feet is to be twenty-four inches in depth and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge will be 10 inches in thickness at the centre of the road, curved on top so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward ; one of which at each end of the bridge must be recessed and hollowed out to receive the machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers and finished with coping as indicated on the plan.

The walls above and below the abutments for a distance of forty feet or more are to be of masonry, arranged to wind gradually round to meet the line of the slope on the respective sides.

The foundation timbers to be of pine, laid level and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments they are to be laid either longitudinally or transversely as may be required.

In all cases the spaces between them must be filled with a good description of puddle or concrete, as may be directed.

The covering plank to be of pine three inches thick, and must be fastened to the timbers with 1¼-inch white oak treenails eight inches long.

SHEET PILES.—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

CRIB WORK.—Between the centre and rest piers, as well as above and below them, and, if directed, above and below the piers for the seat of the bridge, crib work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 16 feet wide at top, increasing downwards on both sides at the rate of one in twenty four, and through the middle of them, longitudinally, a clear water-way of such dimensions must be formed as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge there are in each case to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of the cribs, the bottom to be of 3-inch plank well fastened with pressed spikes, and the top to be formed of pieces not less than 10 inches thick and the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges and are to be framed so as to leave a space of $1\frac{1}{2}$ inch between the different courses. At the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$ inch diameter is to be driven through the dovetail.

Cross Ties—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides, so as to stand eight inches at the neck and 11 inches at the outer end.

Under the head of each tie, in the joint between the courses immediately below it, a block $1\frac{1}{2}$ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long $\frac{7}{8}$ of an inch diameter is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

Longitudinal Ties.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them, and be secured by bolts of similar dimensions in like manner as described for the tranverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails two inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: one at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be four inches thick and 10 inches in width, fastened from the inside with 10-inch spike five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from eight to ten feet or more; but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than three feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the side next the channel.

The whole interior of the crib work, except the water-ways, to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide piers there are to be two ranges of wale timbers of white oak 6 x 12 inches, the upper range to be fastened by means of screw-bolts half an inch diameter, having upset heads let into wrought iron washers countersunk for them. The other range to be seven feet lower and fastened by rag-bolts $\frac{3}{4}$ of an inch diameter, having similar heads and washers to those in the upper range.

The wale pieces to be put on in lengths of from 24 to 40 feet, their upper edges are to be chamfered, and where they connect their ends are to be scarfed, covered with boiler-plate and secured as directed.

For the protection of the structure and piers three clusters of piles are to be driven within range of the centre pier at suitable distances above and below it, they are to be connected by means of thorough-bolts, straps, etc., and stand one foot or more over the cribs, etc., as may be required. Piles are also to be driven for the protection of the crib work placed above and below the seat piers of the bridge.

In case connected crib work is not placed above and below the seat piers of the bridge, the sides, if directed by the Department of Public Works, are to be protected in the following manner :—

FENDERS —are to be constructed on the land side of both the water-ways, extending for some distance above and below the bridge, as represented on the general plan. They are to be formed by means of piles, caps, anchor timbers and wale pieces all of white oak timber. The piles are to be not less than 11 inches diameter at the small end, driven from six to ten feet into the bottom, three in a group, at about 12 feet from centre to centre, and one at the middle of each anchor timber when they exceed 25 feet in length. The caps are to be formed of two pieces each 6 x 10 inches, arranged about eight inches apart, and checked obliquely to receive a dovetail formed on the head of the piles, to each of which they will be secured with wrought iron screw-bolts $\frac{7}{8}$ of an inch diameter, having upset heads and cast iron bevel washers let flush into the outside cap-pieces.

Immediately under the caps the anchor timbers will connect, with a dovetail, the outer piles and be further secured by a thorough screw-bolt of seven-eighths ($\frac{7}{8}$) of an inch diameter, they will bear on the inside pile of the group and the ends extend to the outside of the front cap-pieces, and under them a waling timber of white oak 8 x 10 inches is to be fastened to the same or inside piles with a screw-bolt of one and one-eighth ($1\frac{1}{8}$) inch round iron having upset heads and washers sunk flush as described for the cap-pieces. Where the wale-pieces are scarfed they must be secured to the outer piles with screw-bolts $\frac{7}{8}$ of an inch diameter, with nuts, heads, etc., as described for the others. At seven (7) feet below the top of the cap-pieces another range of waling 8 x 10 inches is to be put on and fastened throughout with bolts in like manner as for the upper tier.

The outer ends of the anchor timbers must be let into the banks for such a distance as may be required, and be secured to mud sills or cross timbers.

The superstructure of the bridge—both for the fixed and movable parts—as well as the machinery for working the latter, will be made a separate contract.

Parties "tendering" should bear in mind that all the works connected with the construction of the piers and abutments of this bridge must be done between the close of navigation of the present year (1877) and the opening of the canal in the spring of

1878; or during the winter in which the water of the summit level of the canal is drawn down as low as possible for these and other purposes.

For the distance previously stated—220 feet—at the place where the bridge works are situated, the excavation required to be done below the surface water line for the widening and deepening, preparing foundations of pier, abutments, etc., will be measured, estimated and paid for as bridge pit excavation.

The bulk sum tendered for unwatering the pit for the bridge foundation must embrace the cost of constructing all coffer dams required to keep out the water, and to guard against leakage, springs or surface drainage, together with the expense of pumping, baling, removing ice and snow and every contingency connected with unwatering the bridge foundation or any other portion of the works during the progress of the operations, and the satisfactory removal of all coffer dams and other tempoary structures at or before the usual time of opening spring navigation.

MORTAR.—The whole masonry of the bridge piers must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half ($1\frac{1}{2}$) of clean, sharp sand to one of cement, and adding as much water as may be required so make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stone and backing must be well washed if clay or other soil adheres to them.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

The present swing bridge is to remain undisturbed until the new structure is in full and efficient working order, when the whole of the old bridge is to be removed, and everything done to clear out the channel to the required capacity.

Contractors are therefore reminded that this work will have to be done at a time when the water in the canal is at its usual height.

The removal of the abutments, guide piles, waling and other timbers at the ends and sides of the bridge, together with that of the swing portion of the structure; the segments, rollers and all other cast as well as wrought iron are all to be embraced in one bulk sum, which must include hauling and placing them where pointed out, within a distance of 1,000 feet from the present bridge site. All the timber, iron, etc., are to remain the property of the Department of Public Works.

In the month of October or November next, the contractors will be called upon to form a clay dam across the old canal at a place south of the Canada Southern Railway. For this work the same rate per cubic yard will be allowed as for excavation over the water surface on the section.

In case it is decided that the water is to be kept in the Feeder between the close of navigation in the autumn of the present year and the opening of the canal in the spring of the year 1878, it will be necessary to shut off the water at the Junction lock and weir. This the contractor will be expected to do at the time and in the manner most likely to effect the object, and with a view to the speedy clearing out of the water-way when required the following spring.

For this purpose, the contractor, if directed, must provide tarpaulings sufficiently large to cover the whole surface of either the upper or lower gates, sluices, etc., of the lock, and extend several feet along the sides of the recesses and bottom at that place, in order that as little clay as possible may be required to form a staunch dam. A like course is to be followed in shutting off the water at the regulating weir.

For these two dams made thoroughly water-tight at the time required, including their maintenance during the winter and the satisfactory removal of the whole material of which they are composed at the time directed in the following spring, contractors are requested to state in their tenders a bulk sum for which they would be willing to undertake this portion of the work.

It is to be clearly and distinctly understood that for a distance of about 100 feet on both sides of the centre line of the Canada Southern Railway, the contractor shall not in any way or shape interfere with the operations of the railway company when constructing the bridge abutments and other works required in connection with the canal crossing at that place, except in so far as making up the west bank of the canal, which must, however, be done at the time and in the manner required by the Department of Public Works.

In all matters connected with the prosecution of the works, the transportation and delivery of all materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding, or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel when passing through the canal may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed drawings, arranged, modified and adapted to the circumstances and the locality, and for all such parts of the structures as may be considered necessary for the full understanding of the design will be furnished as the works proceed.

If any alterations be rendered necessary by any cause, or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, store-houses or any other buildings, or for temporary roads or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to satisfy the Department of Public Works that all the piers, abutments and protection works connected with the road bridge at the Junction can be fully completed by the opening of navigation in the spring of the year 1878. To be certain of this, all the materials required for the works must be provided and delivered and at least one-half of them prepared by the 15th day of November next. Further, the entire arrangements must be such as to fully satisfy the Department of Public Works that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 1st day of June, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 23rd June, 1877.

APPENDIX No. 20.

WELLAND CANAL.

GENERAL SPECIFICATION of work to be done for the Enlargement between the JUNCTION and RAMEY'S BEND.

The canal is to be enlarged to a width of 100 feet at bottom when sunk to a uniform depth of 2 feet below the top of the mitre sill of the lock at Port Colborne; the side slopes throughout to be made 2 horizontal to 1 vertical.

To make the channel of the dimensions above stated a continuous strip of about 50 feet in width for the full depth must be taken off the side of the present west bank for the entire distance, and the bottom of the existing canal sunk from 2 to 3 feet throughout.

The material excavated must be placed along the west side of the canal at such a distance from the centre line and in the manner hereinafter described.

The work will be divided into four sections, three of which—Nos. 29, 30 and 31—are each one mile in length, and No. 32 will be about 4,000 feet long; their respective positions are indicated on the plan exhibited and clearly marked out on the ground.

TOWING PATH—to be formed along the west side of the canal, the front edge of which is to be 98 feet from the centre line, at the height of 24 feet over the bottom, or 22 feet over the mitre sill of Port Colborne Lock. It is to be made 15 feet wide on top, and have an inclination of 12 inches outwards to a ditch formed in the rear or at the toe of the slope of the adjoining bank.

The ditch to be 3 feet wide on top and of such a depth and inclination as will convey the surface water to off-take drains, formed at such intervals apart as circumstances may require.

The present banks are to be removed so as to leave an uniform width of 20 feet back from the front edge of the towing path, and the side slopes made 2 horizontal to 1 vertical.

SPOIL BANKS—to have an inclination outwards of one in twenty, but they are not to be made on ground where the surface inclines towards the canal unless level benches are first cut to form a foundation; they are for the most part to be kept at least 10 feet back from the top edge of the slope of the old bank.

Their tops are not to be raised higher than 10 feet over the level of the towing path for a distance of 160 feet from the centre line of the canal, thence the height may be increased, provided that proper drains, etc., are made to carry off the surface water to the back ditches.

They are invariably to be of an uniform height, and for the most part of a regular width.

Until such new back ditches are formed as may be required to carry off the surface water efficiently, care must be taken that the old ditches are not filled up or the drainage in any way or shape interrupted.

For any damages that may arise from this cause, whether from inattention or otherwise, it is to be clearly and distinctly understood that the contractor will be held strictly and legally liable to the owners of property in the vicinity.

When the natural ground is below the height required for the towing path, the surface must be removed for such a depth as may be directed for the entire space to be occupied by the bank.

All stumps and roots must also be cut and grubbed, which, together with all logs and brush of every description must be taken away, and from the place where the spoil banks are to be formed all trees must be cut down, logs and brush removed or burnt, but so as not to do any damage to the adjacent lands.

Back ditches are to be made where required and of such dimensions as the engineer may direct.

On Section No. 29 a railway bridge crosses the canal which is not to be interfered with until other parts of the section are completed, unless otherwise specially directed by the Department of Public Works; neither is the wharf adjoining this bridge to be disturbed during the first year's operations.

At Lyons' Creek, on Section No. 31, the bottom of the present canal is not to be disturbed for a distance of 50 feet on either side of the culvert until the contractor has been notified to do so by letter.

Near the south end of Section No. 32 the canal crosses a ledge of rock about 250 feet in length, the top of which has to be cut down from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet.

For the removal of this rock the contractor is expected to state a rate per cubic yard in his tender.

When proceeding with the formation of the channel, as well as in the placing of the material in the spoil banks, the contractor must be strictly guided by the lines marked out by the officer in charge.

He must also take great care not to cut into the inside slopes nor to do anything likely to impair the stability of the banks.

The bottom of the present channel when deepened, as well as that of the new work, must be made as level and uniform as possible, so as to insure throughout the full width and depth contemplated.

Above water surface the slopes must be trimmed to the angles already stated, the lines marked out on the ground, and agreeably to the instructions of the engineer in charge.

The operations must be conducted in such a manner as not to interrupt or impede the passage of vessels or in any way injuriously interfere with the navigation, and subject to the canal regulations now in force, or such others as may be adopted and sanctioned by His Excellency the Governor General in Council.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal on the sections above mentioned will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all that portion of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks) at short distances apart along the whole length and breadth of the work. A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

The prices tendered for the different items of excavation must cover the entire cost of clearing, grubbing and mucking, the forming and trimming of all banks, cutting ditches, and everything necessary for the full and satisfactory completion of the work contemplated in this specification.

The contractor must furnish and provide, at his own cost and expense, all excavators, dredging machinery, derricks, scows, plant, tools and labor that may be required to carry on, conduct, execute and complete *one-third part* of all the work to be done on the section or sections allotted to him by the first day of June, 1874, and *two-thirds* of the whole work by the first of August, 1875, and the completion of the entire work on or before the first day of December, 1876.

The party whose tender may be accepted shall be subject to all the clauses and conditions in regard to payments, retained percentage and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada; and to such other special conditions as the nature of the works may, in the opinion of the Minister of Public Works, seem to demand.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 19th December, 1872.

APPENDIX No. 21.

WELLAND CANAL.

SPECIFICATION of the Work to be done on, and connected with, SECTION No. THIRTY-THREE of the Enlargement.

This section is at and in the vicinity of that part of the canal known as Ramey's Bend; it includes all the works connected with the widening and deepening of the channel for a distance of one mile south of where the works lake-ward of the Junction are under contract; the building of side walls; cutting back ditches and other works for drainage; the removal of a slide that occurred in January last (1877,) on the southern part of Section No. 32; together with the construction of an inverted syphon-culvert on Section No. 31, to carry the waters of Lyons' Creek through under the canal, are also to be embraced under the head of Section No. 33.

The bottom of the present channel, as well as that of the enlargement, must throughout be sunk to the depth of four feet below the top of the mitre sills of the present lock at Port Colborne.

The side slopes in clay excavation are to be two horizontal to one vertical, both above and below the water line at all places situated as subsequently described; and the waterway is to be made 100 feet in width at the level of eighteen inches over the bottom line; otherwise a strip fifty feet in width will be taken off the west side.

In *rock excavation* the side slopes are to be one quarter horizontal to one vertical, and the channel made of a mean width of 124 feet below the line of assumed low water of Lake Erie; this will render necessary the removal of a strip of about seventy feet in width along the west side of the principal part of the rock cutting on the section.

When excavating rock where the top of it is not more than six feet above the contemplated bottom of the canal, the side lines of the channel are to correspond with those in clay cutting, except that the slope on the rock thus situated must not exceed one-half horizontal to one vertical. The side slopes must, however, be varied at the places and in the manner subsequently stated.

For about two-thirds of the length of the section, rock will be found before getting to the full depth required, and for about two-fifths of the distance stated the surface of the rock varies from nothing to six feet over the bottom line; the other three-fifths varies from six to sixteen feet over the bottom of the enlarged canal.

The widening of the prism will chiefly be done on the west side of the present line, as indicated in red on the general plan exhibited; the Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined; also of altering the position of the culvert for Lyons' Creek five hundred feet either upward or downward from that represented on the plan, or of placing it in such other position as may be considered most advantageous for the purposes contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The excavation to be done on the section may be set down approximately as follows:—Old spoil bank, consisting of clay and quarry refuse mixed, together with other excavation over present canal surface will, in the aggregate, amount to about *four-fifteenths* of the whole; clay excavation under present water surface, the lower part of which or that next the rock is of a hard nature and mixed with gravel, amounts to about *seven-fifteenths*; rock excavation amounts to about *four-fifteenths* of the whole. It may be stated for the information of parties "tendering," that a considerable portion of the rock excavation consists in lowering the bottom, and that the nature of the rock may be ascertained by an examination of the old spoil banks in the vicinity of the work.

The material excavated in widening and deepening the prism can for the most part be placed on the west side of the canal within the limits of the section and at from 160 to 400 feet from the centre line. Contractors when tendering should, however, bear in mind that unless the material is hauled or in some way carried to the rear of the bank the spoil ground will be found insufficient, especially opposite deep rock cutting. They will therefore be expected to adopt some course of this kind, or be prepared to raise the banks to a higher level and to keep the front side of them at a greater distance back from the water line than that subsequently described.

The material removed from the slide on Section No. 32 can also be placed on the west bank of Section No. 33, but it will have to be taken a distance of from 2,000 to 4,000 feet and will unavoidably have to be handled twice before it can be placed in the required position.

The excavation from the new culvert pit and the parts of the channel on each side of the present one which have still to be widened and deepened to the proper dimension can all be deposited in rear of the present spoil bank on Section No. 31, within a distance of fifteen hundred feet to the south or to the north of where it has been removed. There is, however, good reason to believe that a considerable part if not the whole of this material will have to be handled twice before it can be placed in a suitable position.

Towing Path—to be formed along the west side of the canal, the front edge of which in clay excavation is to be 98 feet from the centre line, at the height of 22 feet over the mitre sill of Port Colborne Lock, and at the same level through rock cutting when it exceeds six feet in depth; the front edge of the towing path will be about 66½ feet from the centre line of the channel. The connections between these two lines are to be formed by two flat reverse curves within a stretch of 150 feet.

It is to be made 15 feet in width on top and have an inclination outward of about twelve inches, to a ditch formed at all places where the bank in rear of it is of a greater height. The ditch to be two feet wide at bottom and have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

In connection with them, where necessary, wells are to be sunk, from which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal two feet or more below the assumed level of Lake Erie. These wells are to be from two to three feet square, and the culverts from them from 15 to 24 inches square; they are to be built of rubble masonry laid in cement mortar; the bottom of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least six inches under the walls on both sides; the covering of the culverts must be of flat stones of a length which will bear at least six inches on the side walls. The wells and channels from them may, however, be formed of timber and plank, and a bridge be made over the outlet if so directed. In either case the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When either the east or west banks are cut into at any place where they pass through or are immediately alongside of low ground, a new bank must be formed or an additional width given to the present one, as circumstances may require. In all such cases the space to be occupied by the bank must be cleared of all stumps, roots and logs; all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the bank, as well as between the new banks and seats prepared for them.

Back Ditches—to carry off the surface water and such other natural drainage as it may be necessary to provide for are to be formed on both sides of the canal, if necessary, at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available. For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

It is further to be clearly and distinctly understood that the new back ditch on the west side of the canal, for the entire length of the section, must be made of its full dimensions, 3 feet wide at bottom, and in every respect fully completed on or before the 1st day of November next, (1877) in order to be prepared to carry off the water that may be pumped from the bed of the canal during the following winter.

The material in the present spoil banks, as well as that at other places above the water surface, which has to be removed, opposite where the rock cutting exceeds four feet or more in depth, must be hauled and deposited at such a distance back from the water line as will admit of placing all the rock excavated from the prism on the east or canal side of the west bank, in the manner herein described.

It will be observed from the position of the work that all the clay portion of it under the water surface, connected with the widening and deepening of the channel, can be done by machinery during summer months, provided proper precautions are taken to guard against interfering with the navigation; contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be fully prepared to excavate, haul, transport and elevate the material in such a manner as will enable it to be expeditiously removed and deposited at the places and in the manner required, unless they are able to show to the satisfaction of the Department of Public Works that they

are in a position to execute the work in some other way in a more expeditious manner, within the time agreed upon for its completion.

When proceeding with the works connected with the widening and deepening of the channel under the water line, great care must be taken not to cut into the inside slopes or to do anything at all likely to have a tendency to impair the stability of the banks.

SIDES AND BOTTOM.—The canal, as before stated, is to have a mean width of 124 feet or a sectional area of 1,860 square feet through both rock and clay excavation below the assumed low water line of Lake Erie. The side slopes must in all cases be trimmed off fairly and smoothly to the respective inclinations previously mentioned, *i.e.* in clay, two horizontal to one vertical; in rock, one-quarter horizontal to one vertical, except where the depth of rock cutting is less than six feet, when its slope must be made one-half horizontal to one vertical, and between the rock and clay parts of the channel the slopes are to vary so as to correspond at one end with the face line of the rock cutting, and at the other end with the clay.

The contractor must invariably be guided by the lines marked out by the officer in charge, and see that all angular and prominent points of rock are broken off so that no part, in any direction, shall project inside of these lines. It should also be borne in mind that in case of there being any protruding or objectionable points of rock on the inner face of the east side within the limits of the section, they must be broken off and removed in like manner as provided for those on the side where the principal part of the widening and deepening is to be done.

For the entire length of the section and width of the channel, the bottom must be sunk to an uniform depth of four feet below the mitre sills of the present lock at Port Colborne, or to a greater depth if rendered necessary by the inclination or thickness of the lower stratum of rock that has to be removed.

SPOIL BANKS.—From the place to be occupied by spoil banks, all standing trees must be cut down, which, together with logs and brush wood, must be removed or burned, care being taken, however, to guard fully against damaging or interfering with the adjoining property.

They are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut to form a foundation.

When the material to be spoiled is clay or earth, it must be kept back at least ten feet from the top edge of the slope of the old bank, and not raised higher than ten feet above the level of the towing path, within a distance of 180 feet from the centre line of channel. Beyond the distance stated, the height may be increased, after suitable drains and other provisions are made to carry the surface water to the back ditches.

On the nature of the seat for the spoil banks, opposite the deep parts of the rock cutting, will, in a great measure, depend their actual position and height. It is, however, intended that their eastern side shall be from 100 to 130 feet west of the centre line of the canal. To enable this to be done, the contractor will be called upon, if necessary, to form a level bench from 12 to 15 feet in width along the front side, down to solid ground; on this the largest and best-shaped stones taken from the excavation are to be piled or placed, in a regular manner, as the works proceed, in order to keep the other material in position.

The expense of forming the trench above mentioned, together with that of placing the outer stones so as to form a sort of rough wall, must be included in the price tendered for rock excavation.

SIDE WALLS.—Where the surface of the rock is six feet or more over the bottom of the canal, the face of the banks above it are to be protected by means of a dry wall, built of large-sized, well-shaped stones, of the best kind that can be found in the excavation.

They are to be 2 feet wide on the top, increasing downward on the face side at the rate of about three inches to the foot, and on the rear side increase at a like rate for the first five feet from the top, thence downward the back is to be plumb.

The stones must be properly bonded over and with each other in the heart of the wall, as well as on both the front and rear sides, and in every course there must be headers of at least 3 feet depth of bed, placed not more than seven feet apart. The face of the stones must be hammered, scabbled or picked to the batter of the wall, unless they are in regular courses, when offsets corresponding to the batter can be made.

The coping stones to be of the full width of the top of the wall (2 feet), in pieces at least 9 inches thick and not less than 3 feet long.

In rear of the walls, (if so directed) a space of about 15 inches in width and for such a depth as may be ordered is to be made up with small stones, quarry waste or gravel, well rammed.

To form a seat for these walls the surface of the rock must be cleaned off, or stripped for the full width required, and the material removed to the spoil bank, for which the contract rate for excavation on the section, corresponding to the position of the work done, will be allowed.

At the end of the deep rock cuttings, the clay parts of the banks of the canal are to be connected with the side walls by means of a wall of varying inclination—at one end adapted to the slope of the bank and at the other end to the batter of the wall.

Parties "tendering" should bear in mind that, included with the removal of the slide on Section No 32, is the deepening of the channel for its full width at that place to the level of two feet below the top of the present mitre sill of Port Colborne Lock. This material, (fully thirty thousand cubic yards) by twice handling, can, as previously stated, be placed in the spoil banks on Section No. 33.

This work the contractor will be called upon to do between the middle of June and the first day of October, 1878. It is to be clearly and fully understood that all the work to be done on this Section (No. 33), for the deepening and widening of the canal, for the removal of the slide and deepening on Section No. 32, and all the excavation connected with the culvert for Lyons' Creek, will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken in each case of those parts of the ground to be removed above the water surface, and accurate soundings made, (with reference to fixed and permanent bench marks) at short distances apart, along the whole length and breadth of that part of the present canal within the boundaries of the section, at the slide on Section *thirty two* and at the culvert on Section *thirty one*.

A duplicate copy of the cross sections made from these levels and soundings will remain on record in the office of the Department of Public Works, and another in the office of the Resident Engineer; from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

LYONS' CREEK CULVERT.

At a place in the vicinity of the present culvert on Section No. 31, or within a distance of three hundred feet either to the south or north of it, a new inverted syphon-culvert is to be built to carry the waters of Lyons' Creek through under the canal.

It is to be 8 feet wide and 6 feet high inside, constructed of masonry laid in hydraulic cement mortar, on a bearing surface of timber and plank; the whole to be fastened and secured in the manner herein described.

The pit for it will be 275 feet in length, 25 feet of which at each end must be made 25 feet in width, and between these points it is to be $18\frac{1}{2}$ feet wide at bottom; the whole to be excavated to an uniform level surface at the depth of $15\frac{1}{3}$ feet below the top of the mitre sill of the present lock at Port Colborne. The sides to be made as nearly vertical as the nature of the material to be removed will admit; but as the contractor must assume the entire risk of all slides that may occur, and the whole expense of their removal, he will be allowed a slope of two horizontal to one vertical for all those parts of the pit outside the water lines of the present canal, and a slope of three horizontal to one vertical between these points or through the present canal.

This allowance for a slope does not in either case apply to rock, if such be found in the bottom.

FOUNDATION TIMBERS—to be of pine 12 inches square, laid 6 inches apart transversely to the culvert, or parallel to the canal, the spaces between them and at their ends must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed as subsequently described; or, if so directed, concrete must be used for that purpose.

For a distance of about 70 feet on each side of the centre line of the canal, two ranges of sub sills 12 × 12 inches are to be laid in trenches cut for their reception, under the floor timbers. They are to be placed so that the centre of each range shall be $5\frac{3}{4}$ feet from the centre line of the culvert.

At every six feet, in both ranges and at places directly opposite each other, for the distance above stated, a tie rod one inch and a half ($1\frac{1}{2}$) or more diameter, is to pass vertically through the sill pieces, and be of a length to extend through the end of a cross-binding piece which rests on the crown of the arch. Tie rods to be alternately of copper and iron, *i. e.* one half the number will be copper and the other half iron. These tie rods to have upset heads and large washers on the under sides of the sill pieces, and their upper ends are to be screwed and have nuts the full strength of the bar; the tops of these sill pieces when laid must be on the same level as the foundation, and form a fair bearing for the floor timbers; the spaces alongside of them must be well filled with puddle, and great care taken to keep the tie rods plumb until they are properly supported by the adjoining work.

Four ranges of sheet piles of 4-inch well-jointed pine plank, chamfered on the edges, 6 feet in length, are to be put in across the foundation and fastened to a floor timber extending 3 feet on each side beyond the line of the walls, one at the inner side of the well at both ends of the culvert and one within ten feet of the toe of the inside slope on both sides of the canal. Trenches of such a depth as directed are to be cut plumb on the proper lines for the sheet piles, and the places must afterwards be filled with the best description of puddle to the height of the adjoining ground.

The floor timbers when laid, after the spaces between them have been well filled with puddle, must be dubbed to an uniform surface to receive the plank, which is to be

3 inches thick, well-jointed with a plane, and when being laid must be driven up close, break joints, and be fastened with white oak treenails 9 inches long and 1½ inches diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber.

In case it is decided to put on a second course of plank between the side walls, the upper one will be 2 inches thick, and the lower course must be dubbed to a fair surface for it, the upper course to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber, on alternate sides of the plank.

MASONRY.—All the stone used in the culvert must be of the best class of approved, sound and durable *gray limestone*, free from seams, drys, shakes, sand-holes and other defects.

The water-way is to be made 8 feet wide between the side walls or abutments, which are 3½ feet high to the springing line of the arch; the latter is to be a circular segment of 2½ feet rise.

All the face work of the water-way and wells at both ends of it are to be of stone of the dimensions, dressed and boucharded, as herein described.

The abutments are to be 4¼ feet thick, carried up to a batter of one in twelve on the outer side, to within 15 inches of the crown of the arch. On the inner or face side they may be made up of three courses, provided the upper course in each case is formed into a skew-back for the springing of the arch, the nose or thin part of all of which stones must be at least eight inches thick and increase gradually for a width of twenty-one inches to the angle suited to the radius of the curvature. At least one of these three courses must be thirty one inches width of bed, and the others twenty one inches, with headers not more than ten feet apart in each course. In all cases the beds and ends of the stones must be full, the arrises kept good, and the whole dressed and laid so that neither the horizontal nor vertical joints shall exceed one-fourth of an inch.

The arch stones must be fully twenty one inches deep, and be at least ten inches thick on the soffit, which must be dressed to correspond to the line of the curve, and the beds be dressed smooth and straight, so as to radiate truly for their full depth (21 inches); their end joints must also be kept full, and the various stones must be of such lengths as to break joints properly over and with each other. The courses must be divided in such a manner that there shall be an equal number on each side of the key-stones, which must be at least ten inches thick on lower side when fitted for the respective places they are to occupy.

In all cases the stones of the different courses of the abutments and arch must break joints over and with each other at least twelve inches, and throughout must be laid in full mortar-beds, and driven up by means of a heavy wooden maul to joints of one-fourth of an inch.

The arch must be formed on properly framed centers, the cost of materials, framing and fitting up of which, together with their complete removal when no longer required, must be embraced in the rate or price tendered for masonry.

For 70 feet on each side of the centre line of the canal, the arch stones from the springing line upwards are to be secured to each other by means of wrought iron dowels one inch and a quarter (1¼") diameter and 3 inches long let one inch and a half into the bed in the centre of each stone, and another in like manner put in at the end joints. The key-stones must also be fastened by dowels let down through checks cut in the beds

of the stones, then moved a few inches, after which the checks are to be thoroughly filled with grout.

The abutment and spandrel walls are to be carried up to within fifteen inches of the crown of the arch, the upper stones of which for 70 feet on each side of the centre line of the canal must be in pieces of not less than ten square feet area, and be laid throughout to moderately close joints.

The well at the west end of the culvert is to be eight feet square at floor line; the breast wall, 7½ feet thick at bottom, is to have a batter of one in twelve on the inside, and be carried up plumb in the rear to within four feet of the bottom of the water-course, where a frost batter will be commenced and carried up with such an inclination as to terminate at the back line of the coping, which is to be 3½ feet in width, and must extend at least one foot into the wall on each side of the water-way.

The wall immediately over the western end of the arch, and also the side walls, are to be 7½ feet in thickness, and that part of each of them next the well is to be of dressed stone, all of which must be properly bonded at the angles and over each other. They are to be carried up to a batter of one in twenty-four on the face to the underside of the coping, and the rear sides of them are to be made vertical up to within five feet of the top bank or adjoining ground, where a frost batter is to be commenced and made to such an inclination as will strike a line 2½ feet back from the respective sides of the well, at or near the surface of the ground.

From the point above mentioned upward, the walls are to be 2½ feet in thickness, faced on both sides, and must be made up of stones the full width (2½ feet) to the underside of the coping, which is to be three feet wide on top, project three inches on each side, and have the top dressed so as to be one inch higher, for a width of nine inches, in the middle than on either face.

The top of the side walls to have an inclination outward of about one and a half horizontal to one vertical, except immediately over the breast wall, where the coping is to be level.

The face stones of the wells must be at least 20 and 30 inches depth of bed in the alternate courses and not less than 2½ feet length of face in line of wall. In every course there must be headers of at least two feet length of face and 3½ feet depth of bed, placed not more than 10 feet apart from centre to centre. In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter, boucharded, and the arrises kept good; the upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least nine inches back from the face. The whole to be dressed so that the horizontal and vertical joints between the stones, when in place, shall not exceed one-fourth of an inch.

BACKING—to consist generally of large well-shaped stones not less than 6 inches in thickness and 3 feet area of bed, laid level in full mortar beds and properly bonded throughout the wall.

The side walls and retaining wall at the outlet on the east side will be similar to those above described, but instead of a breast wall, the bottom is to have a slope upward of about two horizontal to one vertical and be formed of pitched stone 18 inches deep, laid in cement mortar and made 18 inches lower in the middle than at the sides.

The faces of the banks at both ends of the culvert, for a distance of 25 to 35 feet or for such other distance as may be required, are to be protected by pitched stones 15 inches deep, laid dry or in such other way as may be subsequently determined.

For the distance previously mentioned, 70 feet on each side of the centre line of the canal, a range of 12″ x 12″ timber is to extend along on both sides of the culvert, resting on the large flat stones laid on top of the abutments. The tie-rods which pass vertically through the sub sills and walls are also to pass through these longitudinal timbers and cross-pieces of like dimensions, arranged in positions suited for that purpose.

For these cross-pieces checks 3 inches deep are to be cut in the crown of the arch, and the whole must be well bedded in mortar before the fastening nuts are screwed down.

The whole of the space between the line of canal bottom and the masonry, etc., of the culvert for the distance above stated is then to be made up with concrete prepared as herein described, and firmly compressed in thin layers when put in place. On those parts of the culvert to be covered by the banks of the canal the concrete will be 18 inches in depth over the crown of the arch. The spaces on both sides of the trunk of the culvert must be properly cleared out and filled with a good description of puddle, well cut, trodden and pounded. As soon as the adjoining banks will admit, these puddle beds are to be made 3 feet in width, and be continued of that thickness to the height of the crown of the arch. The spaces between the puddle walls and the solid banks must be made up either with material hauled on in carts as provided for banks necessary to be made water-tight, otherwise the material must be laid on in thin layers and well pounded or beaten down, and in this manner carried up also to the height of the crown of the arch. A puddle bed is then to be made 15 feet in width from the side of the concrete over the arch and carried up to canal bottom.

In rear of the side walls of the wells, puddle beds are to be carried up—made two feet in width—as soon as the spaces between the walls and solid ground will admit; the adjoining banks must be well beaten and pounded until the space is sufficiently wide to admit of carts being used to haul on the material.

These puddle walls are to be carried up to within about 7 feet of the natural or finished surface of the ground, when they are to be discontinued, and a space of 15 inches in rear of each of the walls of the wells and retaining walls is to be made up with gravel, small stones or quarry refuse, well rammed.

When making up the embankments at and over the ends of the culvert and at all such places where a bank is to be formed through or alongside of ground that is lower than the canal surface, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding 10 inches in depth at a time;* and, if required, water must be thrown over each layer to assist in consolidating the material.

MORTAR.—The whole masonry of the culvert must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout to be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using one and a half (1½) of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

CONCRETE,—where used, must consist of an approved class of stone broken to cubes of one inch and a quarter (1¼), thoroughly mixed with fresh ground hydraulic cement and clean, sharp sand in such proportions as the materials and works may render necessary. The cement and sand must be reduced to a thin paste before the stones are put into it, and when the whole has been thoroughly incorporated it is to be taken to the place where it is to be used, spread in thin layers and be well pressed down with suitable rammers.

ORDER OF BUILDING.—The culvert may be built in stretches of 50 feet in length at a time; but the arch must be formed in such a manner that, up to the time of closing any part of it, the weight on both sides of the centers shall be as nearly as possible equally distributed.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stones must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE,—wherever required, must be of the best description of material for the purpose that can be obtained at any place within a distance of 500 feet of where it is to be used. It is to be laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form a puddle bed or wall impervious to water.

Parties tendering are requested to bear in mind that the greater part of the trunk of this culvert should be built and the works otherwise connected with it done between the close of navigation this autumn and the opening of it in the spring of 1878, or during the time that the water is shut off at Port Colborne and at the outlet of the Feeder for the purpose of allowing this and other works to be proceeded with.

To enable this arrangement to be fully carried out, all the materials required should be delivered by the middle of November next, and the foundation be dredged out to within a few feet of bottom, by that time, for as great an extent as can be done with safety.

It may also be stated that the wells at both ends of the culvert could with advantage be built before winter sets in this year, if the contractors be in a position to supply and prepare the necessary materials for that purpose. This work must otherwise be done during the following summer, when there will be greater difficulty in forming a junction with the part of the trunk then built, than to connect the trunk with the well at a time when there would be comparatively little water to contend with.

The present culvert is to remain undisturbed until the new one is ready to be brought into efficient use, when the whole of the old culvert is to be removed, and everything done

to clear out the channel to the required capacity. Contractors are therefore reminded that this work will have to be done at a time when the water in the canal is at its usual height, and that it will be paid for by the cubic yard, including the removal of all the timber work connected with the wells and trunk. If the whole of the sides, together with the top and bottom parts be entirely removed, no deduction will be made for the water-ways; but if any part of the bottom is left in place, the sectional area of the water-ways will be deducted.

For the purpose of enabling the works on the section to be proceeded with, side walls to be built for the protection of the banks, the trunk of the new culvert for Lyons' Creek to be constructed, etc., the water, as previously stated, will be shut off at Port Colborne and at the outlet of the Feeder, and the canal will be emptied as nearly as circumstances will permit in the early part of December, 1877, and the water will be allowed to remain out until in April, 1878.

The contractor's arrangements for proceeding with the works must therefore be such that every possible advantage will be taken of the time above mentioned to urge them forward in an energetic and satisfactory manner.

Contractors are, however, distinctly informed that shutting off the water at the places above mentioned, and the drawing of it off at Port Robinson, will not have the effect of laying the bottom of the canal dry, several feet of water will still remain in it.

This unavoidable state of matters should be borne in mind by contractors when "tendering," as well as the fact that the only possible way of getting rid of the water is by pumping, and removing part of it when frozen.

Under any circumstances a dam must be made at the upper end of Section No. 33 to prevent the water passing on to or coming from Section No. 34, and another dam must be made to the north of Lyons' Creek Culvert, on Section No. 31, to guard against water passing on to or coming from Section No. 30.

It is probable that the winter of 1878-79, or the period between the closing of the canal in December, 1878, and the opening of navigation in the Spring of 1879, will also be required for the execution of some of the works south of Section No. 30.

Contractors are, however, hereby distinctly informed that, for the period mentioned, *i.e.*, between December, 1878, and April, 1879, the water level north of Port Colborne will not be drawn down lower than the level of Lake Erie.

This will necessitate the construction of a high dam at each end of the place to be unwatered, and the pumping out of the entire quantity of water between these dams.

For this the contractor is expected to state a bulk sum in the "tender," which must include the maintenance of the dams during the winter, and their entire removal by the time required in April following.

Further, if required, the contractor must again put in two high dams in December, 1879—maintain them during that winter and remove them in April, 1880; all of which, together with the unwatering of the works on the section for the period stated (from early in December, 1879, until in April, 1880), must be included in the bulk sum stated for these purposes in the tender.

If it, however, be decided to shut off the water at Port Colborne and at the outlet of the Feeder in the month of December, 1878, and to draw off the water at Port

Robinson and to allow it to remain out of the canal until in April, 1879, contractors are requested to bear in mind that the Department of Public Works reserves the right of paying only a like sum for these purposes as stated in the accepted "tender" for dams and their removal, together with the unwatering of the section for the period from the early part of December, 1877, until in April, 1878.

When preparing their "tenders," contractors should bear in mind that the respective bulk sums for unwatering the different parts of the works, at the different times stated, must in each case embrace the construction of all dams, their full maintenance and their removal at the time directed, also the providing and fitting up of all pumps and machinery that may be required for that purpose, together with the removal of all snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundation of all structures on or connected with the section must all be included in the respective bulk sums stated in the tender.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil banks and in widening and deepening the channel and other cuttings, except absolutely connected "quarry rock" and detached stone or boulders containing one-half of a cubic yard and upward.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the new cut and banks, forming and grading towing paths, cutting ditches, trimming the sides of both the new and old parts of the cut and work to the required angle, bottoming the whole of the section and works herein described, and completing everything connected with the excavation in a satisfactory and workmanlike manner, agreeably to the foregoing specification and the directions of the officer in charge.

But as the price per cubic yard for each class of work will be an average of the whole of that particular class, within certain limits, progress payments will be made *only* according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in manner following, viz :—For rock excavation down to the level of twelve feet above the mitre sills of the present lock at Port Colborne, *two-thirds* of contract price. For rock excavation, from a line twelve feet above the lock sills at Port Colborne down to present bottom, five-sixths of contract price. For the removal of rock below bottom line of present canal to the full uniform depth required, contract price and proportion of balance, so that when the whole shall have been completed, the aggregate amount shall be the same as if the whole were calculated at the prices stated in the contract.

During the progress of the works the different parts of the *earth* excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the rock or other excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding, or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel when passing through the canal may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed drawings, arranged, modified and adapted to the circumstances and the locality, and for all such parts of the structures as may be considered necessary for the full understanding of the design, will be furnished as the works proceed.

If any alterations be rendered necessary by any cause or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer, for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, store-houses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required, by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 20th day of April, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 28th June, 1877.

APPENDIX No. 22.

WELLAND CANAL.

SPECIFICATION of the work remaining to be done on and connected with SECTION No. THIRTY-THREE of the Enlargement.

RE-LETTING.

This section is at and in the vicinity of that part of the canal known as Ramey's Bend; it includes all the works connected with the widening and deepening of the channel for a distance of one mile south of where the enlargement, lake-ward of the junction, is under contract; the building of side walls; cutting back ditches and other works for drainage. The removal of a slide that occurred in January, (1877) on the southern part of Section No. 32, is also to be embraced under the head of Section No. 33.

The bottom of the present channel, as well as that of those parts where the width is increased, must throughout be sunk to the depth of four feet below the top of the mitre sills of the present old lock at Port Colborne.

The side slopes in clay excavation are to be two horizontal to one vertical, both above and below the water-line, at all places situated as subsequently described, and the water-way is to be made 100 feet in width at the level of eighteen inches over the bottom line. The increased width will chiefly be taken off the west side.

In *rock excavation* the side slopes are to be one-quarter horizontal to one vertical, and the channel made of the mean width of 124 feet below the line of assumed low water of Lake Erie; this will render necessary the removal of a strip of about seventy feet in width at the widest place along the west side of the principal part of the rock cutting on the section.

When excavating rock, where the top of it is not more than six feet above the contemplated bottom of the canal, the side lines of the channel are to correspond with those in clay cutting, except that the slope on the rock thus situated must not exceed one-half horizontal to one vertical. The side slopes must, however, be varied at the places and in the manner subsequently stated.

For fully two-thirds of the length of the section, rock will be found before getting to the full depth required, and for about two-fifths of the distance stated the surface of the rock varies from nothing to six feet over the bottom line; the other three-fifths varies from six to sixteen feet over the bottom of the enlarged canal.

The widening of the prism will chiefly be done as above stated on the west side of the present line, as indicated in red on the general plan exhibited; the Department of Railways and Canals, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The excavation remaining to be done on this section is chiefly as follows :—Old spoil bank, consisting of clay and quarry refuse mixed, and such other excavation over present canal surface as may be necessary for forming and trimming towing path, cutting side ditches, seats and channels for off-take drains, etc. Under the present water surface there will be a considerable extent of clay excavation, the lower part of which or that next the rock, is of a hard nature and mixed with gravel. There are still several stretches of the channel to be widened through rock; but the greater and most difficult part of the rock excavation consists in lowering the bottom of the old parts of the channel, as well as the whole of the increased width, to the full depth of water-way above stated. The nature of the rock may be ascertained by an examination of the old spoil banks on the west side of the section.

The material excavated in widening and deepening the prism can, for the most part, be placed on the west side of the canal within the limits of the section, and at from 160 to 400 feet from the centre line. Contractors when tendering should, however, bear in mind that unless the material is hauled or in some way carried to the rear of the bank, the spoil ground will be found insufficient, especially opposite deep rock cutting. They will therefore be expected to adopt some course of this kind or be prepared to raise the banks to a higher level, and to keep the front side of them at a greater distance back from the water line than that subsequently described.

In case it is found necessary to protect the face of the banks at places where side walls are not built, the contractor will be expected, if so directed, to use part of the stones from the excavation for that purpose, by hauling and placing them on the face of the slope in the manner subsequently described.

The material removed from the slide on Section No. 32 can also be placed on the west bank of Section No. 33; but it will have to be taken a distance of from 2,000 to 4,000 feet, and will unavoidably have to be handled twice before it can be placed in the required position.

Towing Path,- to be formed along the west side of the canal, the front edge of which in clay excavation is to be 98 feet from the centre line, at the height of 22 feet over the mitre sill of the lock now in use at Port Colborne, and at the same level through rock cutting when it exceeds six feet in depth; the front edge of the towing path will be about 66½ from the centre line of the channel. The connection between these two lines are to be formed by two flat reverse curves within a stretch of 150 feet.

It is to be made 15 feet in width on top and have an inclination outward of about twelve inches to a ditch formed at all places where the bank in rear of it is of a greater height. The ditch to be two feet wide at bottom and have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

In connection with them, where necessary, wells are to be sunk, from which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal, two feet or more below the assumed level of Lake Erie. These walls are to be from two to three feet square, and the culverts from them from 15 to 24 inches square; they are to be built of rubble masonry laid in cement mortar; the bottom of both wells and culverts are to be of flat stones of a size to reach across the respective openings, and pass at least six inches under the walls on both sides; the covering of the culverts must be of flat stones, of a length which will bear at least six inches on the side walls. The wells and channels from them may, however, be formed of timber and plank, and a bridge be made over the outlet, if so directed. In either case, the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When either the east or west banks are cut into at any place where they pass through or are immediately alongside of low ground, a new bank must be formed, or an additional width given to the present one, as circumstances may require. In all such cases, the space to be occupied by the bank must be cleared of all stumps, roots and logs; all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the bank, as well as between the new banks and seats prepared for them.

At all such places as it is considered necessary to form a water-tight bank, the material must be hauled on to it in carts or waggons, and laid on in layers not exceeding ten inches in depth at a time, and, if required, water must be thrown over each layer to assist in consolidating the material.

Back Ditches—to carry off the surface water and such other natural drainage as it may be necessary to provide for, are to be formed on both sides of the canal, if necessary, at the places, and of the dimensions required; care being taken that the old ditches are not interfered with, or the drainage in any way interrupted before the new ditches are fully available. For any damages that may arise from this cause, whether the result of inattention, or otherwise, on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

The material in the present spoil banks, as well as that at other places above the water surface, which has to be removed, opposite where the rock cutting exceeds four feet or more in depth, must be hauled and deposited at such a distance back from the water line as will admit of placing all the rock excavated from the prism on the east or canal side of the west bank in the manner herein described.

It will be observed from the position of the work, that all the clay portion of it under the water surface connected with the widening and deepening of the channel can be done by machinery during the summer months, provided proper precautions are taken to guard against interfering with the navigation; contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be fully prepared to excavate, haul, transport and elevate the material in such a manner as will enable it to be expeditiously removed and deposited at the places and in the manner required, unless they are able to show to the satisfaction of the Department of Railways and Canals that they are in a position to execute the work, in some other way, in a more expeditious manner within the time agreed upon for its completion.

When proceeding with the works connected with the widening and deepening of the channel, under the water line, great care must be taken not to cut into the inside slopes, or to do anything at all likely to have a tendency to impair the stability of the banks.

SIDES AND BOTTOM.—The canal, as before stated, is to have a mean width of 124 feet, or a sectional area of 1,860 square feet through both rock and clay excavation below the assumed low water line of Lake Erie. The side slopes must in all cases be trimmed off fairly and smoothly to the respective inclinations previously mentioned, *i.e.*, in clay, two horizontal to one vertical; in rock, one-quarter horizontal to one vertical, except where the depth of rock cutting is less than six feet, when its slope must be made one-half horizontal to one vertical, and between the rock and clay parts of the channel the slopes are to vary so as to correspond at one end with the face line of the rock cutting and at the other end with the clay.

In case it is decided to face part of the banks with stone, the contractor must remove the clay to the width required for that purpose, and for which he will be allowed the same rate per cubic yard as stated in the "tender" for a similar class of work above or below the water line.

The contractor must invariably be guided by the lines marked out by the officer in charge, and see that all angular and prominent points of rock are broken off so that no part, in any direction, shall project inside of these lines. It should also be borne in mind that, in case of there being any protruding or objectionable points of rock on the inner face of the east side, within the limits of the section, they must be broken off and removed in like manner as provided for those on the side where the principal part of the widening and deepening is to be done.

For the entire length of the section and width of the channel, the bottom must be sunk to an uniform depth of four feet below the mitre sills of the present lock at Port Colborne, or to a greater depth if rendered necessary by the inclination or thickness of the lower stratum of rock that has to be removed.

SPOIL BANKS.—From the place to be occupied by spoil banks, all standing trees must be cut down, which, together with logs and brush wood, must be removed or burned, care being taken, however, to guard fully against damaging or interfering with the adjoining property. They are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut to form a foundation.

When the material to be spoiled is clay or earth, it must be kept back at least ten feet from the top edge of the slope of the old bank, and not raised higher than ten feet above the level of the towing path, within a distance of 180 feet from the centre line of channel. Beyond the distance stated, the height may be increased after suitable drains and other provisions are made to carry the surface water to the back ditches.

On the nature of the seat for the spoil banks, opposite the deep parts of the rock cutting, will in a great measure depend their actual position and height. It is, however, intended that their eastern side shall be from 100 to 130 feet west of the centre line of the canal. To enable this to be done, the contractor will be called upon, if necessary, to form a level bench from 12 to 15 feet in width along the front side, down to solid ground; on this, the largest and best-shaped stones taken from the excavation are to be piled or placed in a regular manner as the works proceed, in order to keep the other material in position.

The expense of forming the trench above mentioned, together with that of placing the outer stones so as to form a sort of rough wall, must be included in the price tendered for rock excavation.

SIDE WALLS.—Where the surface of the rock is six feet or more over the bottom of the canal, the face of the banks above it are to be protected by means of a dry wall, built of large-sized well-shaped stones, of the best kind that can be found in the excavation or spoil banks.

They are to be 2 feet wide on the top, increasing downward on the face side at the rate of about three inches to the foot, and at the rear side increase at a like rate for the first five feet from the top; thence downward the back is to be plumb.

The stones must be properly bonded over and with each other in the heart of the wall, as well as on both the front and rear sides, and in every course there must be headers of at least 3 feet depth of bed, placed not more than seven feet apart. The face of the stones must be hammered, scabbled or picked to the batter of the wall, unless they are in regular courses, when offsets corresponding to the batter can be made.

The coping stones to be of the full width of the top of the wall (2 feet), in pieces at least 9 inches thick and not less than 3 feet long.

In rear of the wall (if so directed) a space of about 15 inches in width and for such a depth as may be ordered is to be made up with small stones, quarry waste or gravel, well rammed.

To form a seat for these walls, the surface of the rock must be cleaned off or stripped for the full width required and the material removed to the spoil bank, for which the contract rate for excavation on the section corresponding to the position of the work done will to be allowed.

Where the surface of the rock is less than six feet over the bottom line of the canal, the face of the banks, if so directed, is to be protected by a covering of hand-laid rip-rap stone, varying from 32 inches in depth at bottom to 20 inches in depth at top. The stones forming the face side of the covering are to be pitched and laid so as to present a fair surface; the bottom tiers of stones may be of large dimensions and those on the top are to be laid level and form a moderately fair uniform coping not less than twenty inches in width.

All sharp angular points must be broken off the upper side of the outer stratum of stones, and the interstices between them must be filled with quarry waste, and the whole well pounded and beaten down to a fair surface.

At the foot of the slope, a triangular-shaped timber must, if directed, be bolted to the rock or let into the clay, as the case may be, in order to support the toe stones of the covering.

At the end of the deep rock cuttings, the clay parts of the banks of the canal or the rip-rap facings on the banks are to be connected with the side walls by means of a wall of varying inclination—at one end adapted to the slope of the bank or facing, and at the other end to the batter of the wall.

Parties "tendering" should bear in mind that, included with the removal of the slide on Section No. 32, is the deepening of the channel for its full width at that place to the level of two feet below the top of the present mitre sill of Port Colborne Lock.

This material (fully thirty thousand cubic yards), by twice handling, can, as previously stated, be placed in the spoil banks on Section No. 33. This work the contractor will be called upon to do between the middle of June and the first day of October, 1880. It is to be clearly and fully understood that all the work to be done in this section (No. 33), for the deepening and widening of the canal, for the removal of the slide and deepening on Section 32, will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken in each case of those parts of the grounds to be removed above the water surface, and accurate soundings made (with reference to the fixed and permanent bench marks) at short distances apart, along the whole length and breadth of that part of the present canal and elsewhere within the boundaries of the section and at the slide on Section 32.

A duplicate copy of the cross sections made from these levels and soundings will remain on record in the office of the Department of Railways and Canals and another in the office of the Resident Engineer; from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

To admit of the widening, deepening and other works on the section being proceeded with, the whole of the canal water within its limits must be pumped out as soon after the close of navigation in December next (1879) as circumstances will permit. For the purpose of enabling this to be done, a dam must be constructed at the southern end of the section to prevent water passing on to or coming from Section No. 34, and a dam must also be made at the northern end of the section to prevent water coming from Section No. 32.

Contractors should clearly and distinctly understand that these dams must in both cases be made of sufficient height and strength to admit of the entire section being laid dry when the water on the southern side of the south dam and the northern side of the north dam is two feet higher than the surface water level of Lake Erie.

Immediately after the works have been awarded and a contract entered into with the Department of Railways and Canals, the contractor must make arrangements to provide and prepare all material necessary for the construction of these dams, so as to be ready to put them in place as soon as navigation closes in the early part of December next (1879).

When in place and properly secured they must be maintained by the contractor until in April, 1880, at which time they must be removed by him and at his sole cost and expense, for the full and satisfactory opening of spring navigation.

For the purpose of emptying that part of the canal within the limits of the section, as above stated, and for the removal of surface water, springs, leakage, snow, ice or any other accumulations of water on the line of the works, efficient steam engines and pumps must be provided and placed by the contractor in the most advantageous positions to lift the water and discharge it into the back ditches, or of disposing of it in some other way without allowing it to pass on to Section 34 or on to private property. The entire responsibility of injury to other contractors or to the property of private individuals, it is to be clearly understood, rests with or devolves upon the contractor, who must make good to the respective parties any losses they may sustain from any of his acts, whether the same result from inattention or even a desire to prosecute the works.

For the unwatering of the section as above stated, the contractor is expected to state a bulk sum in the "tender" which must include the expeditious construction of the dams, their maintenance during winter and their removal by the time required

in April, 1880. Further, if required for the full and satisfactory completion of the works embraced in the section, the contractor must again put in two high dams in December, 1880—maintain them during that winter and remove them fully in April, 1881; all of which, together with the unwatering of the works on the section for the period stated (early in December, 1880, until in April, 1881), must be included in the bulk sum stated for these purposes in the "tender."

When preparing their "tenders," contractors should bear in mind that the respective bulk sums for unwatering the different parts of the works at the different times stated must, in each case, embrace the construction of all dams, their full maintenance and their removal at the time directed; also the providing and fitting up of all pumps and machinery that may be required for that purpose, together with the removal of all water, snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundation of all structures on or connected with the section, must all be included in the respective bulk sums stated in the tender.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil banks and in widening and deepening the channel and other cuttings, except absolutely connected "quarry rock" and detached stone or boulders containing one-half of a cubic yard and upward.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the cuttings and banks, forming and grading towing paths, cutting ditches, trimming the sides of both the new and old parts of the cut and work to the required angle, bottoming the whole of the section and works herein described, and completing everything connected with the excavation in a satisfactory and workmanlike manner, agreeably to the foregoing specification and the directions of the officer in charge.

But as the price per cubic yard for each class of work will be an average of the whole of that particular class, within certain limits, progress payments will be made *only* according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in manner following, viz:—For rock excavation down to the level of twelve feet above the mitre sills of the present lock at Port Colborne, *two-thirds* of contract price. For rock excavation from a line twelve feet above the lock sills at Port Colborne down to present bottom, five-sixths of contract price. For the removal of rock below bottom line of present canal to the full uniform depth required, contract price and proportion of balance, so that when the whole shall have been completed the aggregate amount shall be the same as if the whole were calculated at the prices stated in the contract.

During the progress of the works the different parts of the "earth" excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

Before tendering, contractors are invited to examine the engine, boiler and pump situated at the north end of Section No. 33, and said to be in place, as used last winter for unwatering the works. The pump (centrifugal) has a 15-inch discharge pipe, and, as a whole, together with the engine, is said to be in ordinary fair working condition; but the boiler is in a less serviceable state. It requires a new furnace, and either new tubes or those that are in it taken out and cleaned, together with other repairs, before it can be advantageously used.

Contractors should, however, look into this important matter closely before arriving at a conclusion, as they are expected to state a bulk sum which they would be willing to

give for the use of this pump, engine and boiler from December, 1879, to the latter end of April, 1880, and from December, 1880, to the end of April, 1881; at the same time bearing in mind that the whole must be put in full and efficient working order, and maintained in that condition during the time that they are required for the contemplated service.

It is also to be distinctly understood that about the end of April, 1881, the contractor must take up the pump, carefully arrange the engine works, and place the whole of the equipment in such a position on the banks of the canal that it can be readily removed.

Nevertheless, if the contractor is able to show to the full satisfaction of the Department of Railways and Canals that he either has, or can procure, equally as good or a better equipment for pumping, and have it fitted up at the place by the time it is required, then the renting or leasing of the pump, etc., at present on the section, may not be insisted upon.

In all matters connected with the prosecution of the works, the transportation and delivery of plant or materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the rock or other excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Railways and Canals, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Railways and Canals that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 20th day of April, 1881.

JOHN PAGE,
Chief Engineer of Canals.

OTTAWA, 29th October, 1879.

APPENDIX No. 23.

WELLAND CANAL.

SPECIFICATION of the Work Remaining to be done on Section No. THIRTY-FOUR of the Enlargement.

RE-LETTING.

This section extends fully two-fifths of a mile north from the line of Main Street, in the Village of Stonebridge, and southward to the centre of the 1st Concession road allowance, in the Township of Humberstone, making altogether a distance of nearly one mile.

The works upon it consist chiefly in widening and deepening the prism of the canal; the construction of the abutments and piers for a road bridge on line of Main Street, in the Village of Stonebridge; building side walls where required; cutting back ditches; grading towing path, and doing such other works as herein described or that may be required.

The bottom of the present channel as well as that of the enlargement must throughout be sunk to the depth of four feet below the top of the mitre sills of the present lock at Port Colborne.

The side slopes in clay excavation are to be two horizontal to one vertical, both above and below the water line at all places situated as subsequently described, and the water-way is to be made 100 feet in width at the level of eighteen inches over the bottom line.

In rock excavation the side slopes are to be one-quarter horizontal to one vertical, and the channel made of a mean width of 124 feet below the assumed low-water line of Lake Erie. This will require an increase of about 70 feet beyond the present width of the channel through those parts of the section on which the rock cutting is deep.

When excavating rock where the top of it is not over 6 feet higher than the contemplated bottom of the canal, the side lines of the channel are to correspond with those in

clay cutting, except that the slope on the rock thus situated must not exceed one-half horizontal to one vertical. The side slopes must, however, be varied at the places and in the manner subsequently described.

For nearly the whole length of the section the bottom will be in rock cutting; but toward the north end, for about one-fourth of the full distance, the rock will not exceed from two to six feet in depth above the bottom line. For the other three-fourths of the section the surface of the rock is considerably higher, and at some places it is within two feet of the level of the towing path.

At the north end of the section the increased width of the channel will be taken off the west side of the present line, except some projecting points and trimming on the east side; thence the width of cutting on that side gradually diminishes and increases on the east side until at about 500 feet north of Main Street Bridge, when fully three-fourths of the widening will be done on the east side; thence southward the increased width will be taken off both sides, but gradually diminishing on the west side until at the south end of the section the widening is to be done chiefly on the east side, as indicated in red on the general plan exhibited.

The Department of Railways and Canals, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width equally or otherwise on both sides, as may be subsequently determined; also of altering the position of the piers and abutments of the swing bridge, and of placing them either more or less oblique to the centre of the canal than represented, or at right angles to it, as may be considered most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The excavation still to be done on this section is chiefly as follows:—Old spoil bank, consisting of clay and quarry refuse mixed, clay, muck and other materials overlying the rock, and such other excavation over present water surface as may be necessary to form a road along the east side and a towing path on both sides of the canal, trimming the same, cutting side ditches, seats and channels for off-take drains, etc. At north end of the section there will be some clay excavation under the water line. At nearly every place the excavation next the rock is of a hard nature and mixed with gravel. At some places the widening has already been partly done, but the greater part has still to be done; the most difficult part of the rock excavation consists in lowering the bottom of the old parts of the channel, as well as the whole of the increased width, to the full depth of water-way above stated, except at the site of the bridge at Stonebridge, where the bottom has been sunk to the full depth and nearly to the full width.

The nature of the rock may be ascertained by an examination of the spoil banks on the west side of the section.

For a distance of about 1,400 feet from the north end of the section, the material excavated in widening and deepening the channel can be deposited on the west side of the canal at from 160 to 400 feet from the centre line, provided that a considerable part of it is hauled or in some way carried to the rear of the bank.

From Augustine's old saw-mill southward to the line of Thompson Street, there is no convenient spoil ground of any extent to be had on either the east or west sides of the

canal, and from the south end of the section to the line of Thompson Street there is no available spoil ground on canal property.

Parties tendering should clearly and distinctly understand that contractors will not be allowed the use of the lock at Port Colborne to pass scows, carrying clay, mud, rock or spoil of any kind from this section; "tenders" for the excavation will therefore be received in two different forms, as follows :—

1.—On the understanding that from the north end southward the contractor should have 1,400 lineal feet on the west side of the canal for spoil ground, the balance of the material excavated to be placed at distances varying from 500 to 2,000 feet back from the water line on spoil ground provided by the Department of Railways and Canals on either the east or west sides of the canal, or at such other places within these distances as may be subsequently decided and within a stretch of two and a half miles along the canal from the south end of the section.

2.—On the understanding that after the spoil ground at the north end of the section 1,400 feet in length on the west side of the canal shall have been used to the extent and in the manner herein described, and the banks of the canal, bridge, approaches, etc., are made to the full height and width required, the contractor shall find, *at his own cost and expense*, deposit ground for all other parts of the material excavated from the widening and deepening of the canal, and from the foundations of structures, etc., as may not be required by the Department of Railways and Canals for embankments or for other purposes.

Contractors are requested to bear in mind that whichever of these two offers is accepted, it embraces the distinct understanding that where the road on the east side of the canal is likely to be cut away either in part or as a whole, the contractor must first provide a satisfactory way for the public travel to pass freely and safely by levelling up or cutting down the tops of spoil banks or whatsoever is necessary to effect the object, all of which must be embraced in the price tendered for excavation.

In case it is found necessary to protect the face of the banks at places where side walls are not built, the contractor will be expected, if so directed, to use part of the stones from the excavation for that purpose by hauling and placing them on the face of the slope in the manner subsequently described.

Towing Path—to be formed along the west side of the canal, the front edge of which, in clay excavation, is to be 98 feet from the centre line, at the height of 22 feet over mitre sill of Port Colborne Lock and at the same level through rock cutting when it exceeds six feet in depth; the front edge of the towing path will be about 66½ feet from the centre line of the channel. The connections between these two lines are to be formed by two flat reverse curves within a stretch of 150 feet.

It is to be made 15 feet in width on top and have an inclination outward of about twelve inches, to a ditch formed at all places where the bank in rear of it is of a greater height. The ditch to be two feet wide at bottom and have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

In connection with them, where necessary, wells are to be sunk, from which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal two feet or more below the assumed level of Lake Erie. These wells are to be from two to three feet square and the culverts from them from 15 to 24 inches square; they are to be built of

rubble masonry laid in cement mortar, the bottom of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least six inches under the walls on both sides; the covering of the culverts must be of flat stones of a length which will bear at least six inches on the side walls. The wells and channels from them may however be formed of timber and plank, and a bridge be made over the outlet if so directed. In either case the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When either the east or west banks are cut into at any place where they pass through or are immediately alongside of low ground, a new bank must be formed or an additional width given to the present one as circumstances may require. In all such cases the space to be occupied by the bank must be cleared of all stumps, roots and logs; all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the bank, as well as between the new banks and seats prepared for them.

At all such places as it is considered necessary to form a water-tight bank, the material must be hauled on to it in carts or waggons and laid on in layers not exceeding ten inches in depth at a time; and, if required, water must be thrown over each layer to assist in consolidating the material.

BACK DITCHES—to carry off the surface water and such other natural drainage as it may be requisite to provide for are to be formed on both sides of the canal if necessary, at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available. For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

It is further to be clearly and distinctly understood that the new back ditch on the west side of the canal from the north end of the section to Stonebridge must be made of its full dimensions, 3 feet wide or more at bottom, and in every respect fully completed where not already done; also all that part of the present ditch from Stonebridge to the end of the section cleared out or a new one made in its stead on or before the 10th day of December next (1879), in order to be prepared to carry off the water that may be pumped from the bed of the canal during the next and following winters.

The material in the present spoil banks, as well as that at other places above the water surface which has to be removed at the north end of the section opposite where the rock cutting exceeds four feet or more in depth, must be hauled and deposited at such a distance back from the water line as will admit of placing all the rock excavated from the prism at that place on the east or canal side of the west bank in the manner herein described.

When proceeding with the works connected with the widening and deepening of the channel under the water line, great care must be taken not to cut into the inside slopes, or to do anything at all likely to have a tendency to impair the stability of the banks.

SIDES AND BOTTOM.—The canal, as before stated, is to have a mean width of 124 feet or a sectional area of 1,860 square feet through both rock and clay excavation below the assumed low-water line of Lake Erie. The side slopes must in all cases be trimmed off fairly and smoothly to the respective inclinations previously mentioned, *i.e.*, in clay two horizontal and one vertical, in rock one quarter horizontal to one vertical, except where the depth of rock cutting is less than six feet, when its slope must be made one half horizontal to one vertical, and between the rock and clay parts of

the channel the slopes are to vary so as to correspond at one end with the face line of the rock cutting and at the other end with the clay.

In case it is decided to face part of the banks with stone, the contractor must remove the clay to the width required for that purpose and for which he will be allowed the same rate per cubic yard as stated in the tender for a similar class of work above or below the water line.

The contractor must invariably be guided by the lines marked out by the officer in charge, and see that all angular and prominent points of rock are broken off so that no part in any direction shall project inside of these lines. It should also be borne in mind that in case of their being any protruding or objectionable points of rock on the inner face of the east side within the limits of the section, they must be broken off and removed in like manner as provided for those on the side where the principal part of the widening and deepening is to be done.

For the entire length of the section and width of the channel the bottom must be sunk to an uniform depth of four feet below the mitre sills of the present lock at Port Colborne, or to a greater depth if rendered necessary by the inclination or thickness of the lower stratum of rock that has to be removed.

Spoil Banks.—From the place to be occupied by spoil banks, all standing trees must be cut down, which, together with logs and brushwood must be removed or burned, care being taken, however, to guard fully against damaging or interfering with the adjoining property.

They are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut to form a foundation.

When the material to be spoiled is clay or earth, it must be kept back at least ten feet from the top edge of the slope of the old bank and not raised higher than ten feet above the level of the towing path within a distance of 180 feet from the centre line of channel. Beyond the distance stated the height may be increased after suitable drains and other provisions are made to carry the surface water to the back ditches.

On the nature of the seat for the spoil banks opposite the deep parts of the rock cutting will, in a great measure, depend their actual position and height. It is, however, intended that the eastern side of those on the west side should be from 100 to 130 feet west of the centre line of the canal, but where rock is near the surface or the material over it is of a hard nature the spoil bank may be from 90 to 110 feet back from the centre line. To enable this to be done the contractor will be called upon, if necessary, to form a level bench from 12 to 15 feet in width along the front side down to solid ground; on this the largest and best-shaped stones taken from the excavation are to be piled or placed in a regular manner as the works proceed in order to keep the other material in position, and between Stonebridge and the south end of the section a similar rough wall will also have to be made on the west side of the spoil ground.

Spoil Banks,—when or wheresoever made on the east side of the canal, must have their west side at least 150 feet east of the centre line of the channel, or be at such other distance from it as may be required to allow for the necessary space for a towing path and road-way. A seat for the front edge of the bank in either case must be prepared as above stated.

The expense of forming the trench or trenches above mentioned, together with that of placing the outer stones so as to form a sort of rough wall, must be included in the prices tendered respectively for earth and rock excavation.

The spoil banks must, as nearly as circumstances will admit, be made of an uniform height; those formed of clay must generally have a declivity toward the back ditch of about one in twenty, and for the most part be of a regular width.

SIDE WALLS.—Where the surface of the rock is six feet or more over the bottom of the canal, the face of the banks above it are to be protected by means of a dry wall built of large-sized well-shaped stones of the best kind that can be found in the excavation or spoil banks.

They are to be two feet wide on the top, increasing downward on the face side at the rate of about three inches to the foot, and on the rear side increase at a like rate for the first five feet from the top, thence downward the back is to be plumb.

The stones must be properly bonded over and with each other in the heart of the wall, as well as on both the front and rear sides, and in every course there must be headers of at least three feet depth of bed placed not more than seven feet apart. The face of the stones must be hammered, scabbled or picked to the batter of the wall, unless they are in regular courses, when offsets corresponding to the batter can be made.

The coping stones to be of the full width of the top of the wall (2 feet), in pieces at least 9 inches thick and not less than 3 feet long.

In rear of the walls (if so directed) a space of about 15 inches in width and for such a depth as may be ordered is to be made up with small stones, quarry waste or gravel, well rammed.

To form a seat for these walls, the surface of the rock must be cleaned off or stripped for the full width required, and the material removed to the spoil bank, for which the contact rate for excavation on the section corresponding to the position of the work done will be allowed.

When the surface of the rock is less than 6 feet over the bottom line of the canal, the face of the banks, if so directed, is to be protected by a covering of hand-laid rip-rap stone varying from 32 inches in depth at bottom to 20 inches in depth at top. The stones forming the face side of the covering are to be pitched and laid so as to present a fair surface; the bottom tiers of stones may be of large dimensions, and those on the top are to be laid level and form a moderately fair uniform coping not less than twenty inches in width.

All sharp angular points must be broken off the upper side of the outer stratum of stones, and the interstices between them must be filled with quarry waste, and the whole well pounded and beaten down to a fair surface.

At the foot of the slope, a triangular-shaped timber must, if directed, be bolted to the rock or let into the clay, as the case may be, in order to support the toe stones of the covering.

At the end of the deep rock cuttings, the clay parts of the banks of the canal or the rip-rap facings on the banks are to be connected with the side walls by means of a wall of varying inclination at one end adapted to the slope of the bank or facing, and at the other end to the batter of the wall.

It is to be clearly and distinctly understood that the whole of the work to be done for the widening and deepening of the canal, excavation for bridge, etc., etc., will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced,

levels will be taken of all those portions of the ground to be removed over the water surface, and accurate soundings made with reference to fixed and permanent bench-marks at short distances apart along the whole length and breadth of the section. A duplicate copy of the cross sections made from these levels and soundings is to remain on record in the office of the Department of Railways and Canals and another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

ROAD BRIDGE—This includes the construction of the abutments and piers for a swing bridge, intended to serve as a means of crossing the enlarged canal on the line of Main Street in the Village of Stonebridge.

The water-way is to be in *three* divisions, the two eastern ones of which are each to be 46 feet wide at the assumed low-water line of Lake Erie and form the navigable channels.

The piers and abutments are to be of masonry laid in hydraulic cement mortar, built chiefly in the form, of the dimensions and in the manner herein described or as may be subsequently directed.

The bridge being situated at a place where the canal is cut through rock, the foundation will be on the same level as the bottom of the reach, unless it is found that the nature of the rock renders a greater depth necessary.

The bearing or centre pier and the rest piers of the bridge are to be as nearly as possible parallel to the centre line of the canal, the former to be 16 feet square and the latter 16 feet in width and 9 feet thick at top. Through each of them an arched culvert 6 feet wide and 8 feet in height is to be made on a line ranging with the water-way.

The canal and line of street being oblique to each other, the bridge will either be suited to the range of the latter or placed about mid-way between that angle and a right angle to the centre line of the canal as may be subsequently determined.

The west pier which forms the seat of the swing portion of the bridge when in position is to be 11¼ feet thick at bottom, the sides of which are to be parallel to the canal, and the ends made at right angles to the face. It is to be faced on both sides and throughout be of a like class of materials and workmanship as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty-four.

At four feet from the top of this pier, or at such other height as may be required, an offset is to be formed on the front side for the bridge seat.

The abutments are to be of masonry, commenced either at canal bottom or at such a height above it as warranted by the nature and soundness of the rock. The east abutment, at whatever height it is started, must occupy such a position that at 5 feet above the canal bottom the line of its face produced shall not at any place, within a distance of 300 feet on either side of it, be inside of the line of the canal. It is to be carried up to a batter of one in twenty-four on the face, and at top an offset is to be made for the bridge seat; the wall is to be 7½ feet or more in thickness at bottom, be made plumb in the rear to within five feet of the top, thence diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the pier and the backing of large-sized well-shaped stones laid level in full mortar beds and properly bonded throughout the wall.

The west abutment is to be of a similar class of work to that above described.

The arch stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth and made to lay throughout to joints of one-fourth ($\frac{1}{4}$) of an inch. The bottom part of the arch or water-way is to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening and the end of each pass 15 inches under the wall; the second course to project one foot into the opening on each side, and the third to project inward 6 inches.

The face stones of the piers to be 2 and 3 feet depth of bed in alternate courses, with headers in every course $4\frac{1}{2}$ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth ($\frac{1}{4}$) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers. In each case they are to have a batter of one in twenty-four.

The heart of the wall must invariably be made up with flat-bedded stones not less than 4 feet area of bed and of the full height of the face stones; their beds and joints must be scabbled or picked if necessary, so that when laid the horizontal joints shall not exceed five-eighths ($\frac{5}{8}$) of an inch, and the vertical joints be not more than one inch and a quarter.

The centre pier, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top side must have a fair surface neatly boucharded and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least $3\frac{1}{2}$ feet in length.

In the centre of the rest piers one of the coping stones for a width of four feet is to be twenty four inches in depth and checked to the curve of the toe of the bridge. This in each case must be secured with fox-wedged bolts $1\frac{1}{2}$ inches diameter let into the masonry underneath.

The coping on the pier for the seat and the abutments of the road bridge will be 10 inches in thickness at the centre of the road, curved on top so as to be 8 inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built $4\frac{1}{2}$ feet square at base, diminishing upward—one of which at each end of the bridge must be recessed and hollowed out to receive the machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers and finished with coping as indicated on the plans.

The walls above and below the abutments for a distance of 40 feet or more are to be of masonry arranged to wind gradually round to meet the line of the slope on the respective sides.

CRIB WORK.—Between the centre and rest piers as well as above and below them and, if directed, above and below the pier for the seat of the bridge, crib work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 16 feet wide at top, increasing downwards on both sides at the rate of one in twenty-four, and through the middle of them longitudinally a clear water-way must be formed of such dimensions as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the pier for the seat of the bridge there are in each case to be left two or more openings on the upper and the lower sides. The sides of these openings are to be formed, framed and secured in like manner as the face work of the cribs, the bottom to be of 3-inch plank well fastened with pressed spikes and the top to be formed of pieces not less than 10 inches thick and the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges, and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$ inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides, so as to stand eight inches at the neck and 11 inches at the outer end.

Under the head of each tie, in the joint between the courses immediately below it, a block $1\frac{1}{2}$ x 12 x 12 inches is to be inserted, to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them, and be secured by bolts of similar dimensions, in like manner as described for the transverse ties, into which they are to be notched, and fastened at the crossings by means of white oak treenails two inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: one at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be four inches thick and 10 inches

in width, fastened from the inside with 10-inch spike five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces, and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from eight to ten feet or more; but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of same range below.

In the first course of side timbers, the cross ties are to be placed not more than 3 feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are, in all cases, to splay 5 feet or more on the side next the channel.

The whole interior of the crib work, except the water-ways, to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide piers there are to be two ranges of wale timbers of white oak 6 x 12 inches; the upper range to be fastened by means of screw-bolts half an inch diameter, having upset heads let into wrought iron washers counter-sunk for them. The other range to be seven feet lower, and fastened by rag-bolts $\frac{3}{4}$ of an inch diameter, having similar heads and washers to those in the upper range.

The wale pieces to be put on in lengths of from 24 to 40 feet; their upper edges are to be chamfered, and where they connect their ends are to be scarfed, covered with boiler-plate and secured as directed.

For the protection of the structure and piers, three clusters of detached oak timbers are to be placed vertically within range of the centre pier, at suitable distances above and below it; their ends are to be let into the rock underneath to a depth of 6 feet at least, or such other depth as circumstances may require. On the lower end of each timber a band of wrought iron $3\frac{1}{2}'' \times \frac{1}{2}''$ is to be fitted, and a bar of iron 2 inches diameter is to pass vertically 12 inches into the timber and 18 inches into the rock; they are further to be fastened by means of knees, straps and bolts, in the most secure manner that their position, etc., will admit of adopting. At the top they are to be connected by means of thorough-bolts, straps and otherwise, and stand one foot or more over the cribs, as may be required. Vertical timbers are also to be arranged and secured in like manner, for the protection of the crib work placed above and below the western seat pier. The spaces between the vertical timbers and the openings around them to be filled in with concrete to the height of canal bottom.

On the east side a range of floating fender timbers is to be constructed on both the north and south sides of the abutment; otherwise, lines of fixed fenders may be placed there, and secured by anchor timbers let into the bank, as circumstances may require.

The superstructure of the bridge, both for the fixed and movable parts, as well as the machinery for working the latter, will be made a separate contract.

MORTAR.—The whole masonry of the bridge piers and abutments must be laid in mortar made of the best Canadian hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate

use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout to be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half ($1\frac{1}{2}$) of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of $1\frac{1}{4}$ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

When the works are in progress the walls must be kept free from all improper materials, and both the face stone and backing must be well washed if clay or other soil adheres to them.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time. The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course must be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

Parties "tendering" are requested to bear in mind that the former contractor for this section made arrangements for certain materials, and the preparation of them, for the bridge works above described; on those delivered in the vicinity of where they are required the sum of $13,154 has been advanced or will be paid for them by the Department of Railways and Canals; this amount will therefore be deducted from the progress estimates, as well as in the final settlement with the contractor who undertakes the full completion of the works.

It should also be borne in mind that all the masonry of the piers and abutments of this bridge, as well as the crib work and protection works connected with it, must be done between the close of navigation of the present year (1879) and the opening of the canal in the spring of 1880.

At the close of navigation, in December next, the contractor must provide a convenient means of crossing the canal at a place within a short distance south of Main Street, near where a temporary crossing was formed last winter.

This temporary bridge must be of trestle work, have at least five longitudinal stringers of timber 11 x 11 inches, be covered with three-inch plank, and be built of sufficient width, have suitable approaches at both ends, have a strong hand-railing on both sides of it, and be in all respects satisfactorily arranged and adapted to accommodate with safety the public travel.

It is further to be clearly and distinctly understood that he (the contractor) shall be held strictly and legally liable and responsible for keeping this crossing in such a condition that it can be safely used during the whole time the new bridge works are in progress, and that he will remove it in time for the opening of navigation in the spring following

the winter in which it has been in use, the whole to be done for the bulk sum stated in the tender for that purpose.

To admit of the widening and deepening of the prism of the canal to be proceeded with ; side walls for the protection of the banks to be built ; the piers and abutments of the bridge at the Village of Stonebridge to be constructed, etc., the whole of the canal water within the limits of the section must be pumped out as soon after the close of navigation in December next (1879) as circumstances will permit. For the purpose of enabling this to be done, a dam must be constructed at the southern end of the section to prevent water passing on to or coming from Section No. 35, and a dam must also be made at the northern end of the section to prevent water passing on to or coming from Section No. 33.

Contractors should clearly and distinctly understand that these dams must in both cases be made of sufficient height and strength to admit of the entire section being laid dry when the water on the southern side of the south dam and on the north side of the north dam is 2 feet higher than the surface water level of Lake Erie.

Immediately after the works have been awarded and a contract entered into with the Department of Railways and Canals, the contractor must make arrangements to provide and prepare all materials necessary for the construction of these dams, so as to be ready to put them in place as soon as navigation closes in the early part of December next (1879).

When in place and properly secured, they must be maintained by the contractor until in April, 1880, at which time they must be removed by him, at his sole cost and expense, for the full and satisfactory opening of spring navigation.

For the purpose of emptying that part of the canal within the limits of the section, as above stated, and for the removal of surface water, springs, leakage, snow, ice or any other accumulations of water on the line of the works, efficient steam engines and pumps must be provided, and placed by the contractor in the most advantageous positions to lift the water and discharge it into the back ditches, or of disposing of it in some other way without allowing it to pass on to Sections Nos. 33 or 35, or on to private property. The entire responsibility of injury to other contractors, or to the property of private individuals it is to be clearly understood, rests with or devolves upon the contractor, who must make good to the respective parties any losses they may sustain from any of his acts, whether the same result from inattention or even a desire to prosecute the works.

For the unwatering of the section as above stated, the contractor is expected to state a bulk sum in the " tender," which must include the expeditious construction of the dams, their maintenance during winter and their removal by the time required in April, 1880. Further, if required for the full and satisfactory completion of the works embraced in the section, the contractor must again put in two high dams in December, 1880, maintain them during that winter and remove them fully in April, 1881 ; all of which, together with the unwatering of the works on the section for the period stated (early in December, 1880, until in April, 1881) must be included in the bulk sum stated for these purposes in the " tender."

When preparing their " tender," contractors should bear in mind that the respective bulk sums for unwatering the different parts of the works, at the different times stated, must in each case embrace the construction of all dams, their full maintenance and their removal at the time directed, also the providing and fitting up of all pumps and machinery that may be required for that purpose, together with the removal of all water, snow and ice ; and every expense directly or indirectly connected with unwatering all the different parts of the work and the foundations of all structures on or connected with the section, must all be included in the respective bulk sums stated in the tender.

There are to be only two classes of denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil banks, and widening and deepening the channel and other cuttings, except absolutely connected "quarry rock" and detached stone or boulders containing one-half of a cubic yard and upward.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the new cut and banks, forming and grading towing paths, cutting ditches, trimming the sides of both the new and old parts of the cut and work to the required angle, bottoming the whole of the section and works herein described, and completing everything connected with the excavation in a satisfactory and workmanlike manner, agreeably to the foregoing specification and the directions of the officer in charge.

But as the price per cubic yard for each class of work will be an average of the whole of that particular class, within certain limits, progress payments will be made *only* according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in manner following, viz:—For rock excavation down to the level of 12 feet above the mitre sills of the present lock at Port Colborne, *two-thirds* of contract price. For rock excavation from a line twelve feet above the lock sills at Port Colborne down to present bottom, five-sixths of contract price. For the removal of rock below bottom line of present canal to the full uniform depth required, contract price and proportion of balance, so that when the whole shall have been completed, the aggregate amount shall be the same as if the whole were calculated at the prices stated in the tender and contract.

During the progress of the works, the different parts of the *earth* excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

It is to be clearly and fully understood that all the work to be done on this section (No. 34), for the widening and deepening of the canal, will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken in each case of those parts of the ground to be removed above the water surface, and accurate soundings made (with reference to fixed and permanent bench marks), at short distances apart, along the whole length and breadth of that part of the present canal and elsewhere within the boundaries of the section.

A duplicate copy of the cross sections made from these levels and soundings will remain on record in the office of the Department of Railways and Canals, and another in the office of the Resident Engineer; from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

Before tendering, contractors are invited to examine the engine, boiler and pump situated near the north end of the section (No. 34) said to be in place as used last winter in connection with unwatering the works; they (intending contractors) are also invited to examine the pumping equipment lying on the east side of the canal at a short distance south of Stonebridge, which is not in place. In both these cases the machinery, but especially the boilers, will no doubt require considerable repairs before they can be advantageously used.

There is also a pump with the necessary working equipment near the north end of Section No. 35, placed there, it is understood, by a mutual agreement between the former contractor for Section No. 34 and the contractors for Section No. 35, the whole of which, it is said, with ordinary repairs, can be placed in good working order. Parties intending

to tender must ascertain for themselves the nature of the agreement made between the late contractor for Section No. 34 and the contractors for Section No. 35, and be certain that the offer made for this pump and its equipment, if accepted, will not in any way interfere with existing arrangements.

Intending contractors should look into these important matters closely before arriving at a conclusion, as they are expected to state a bulk sum that they would be willing to give for the use of each of these three different pumps and its respective equipment from December, 1879, to the latter end of April, 1880, and from December, 1880, to the end of April, 1881, at the same time bearing in mind that the respective pumps and their equipment must be put in full and efficient working order and maintained in that condition during the time they are required for the contemplated service.

It is also to be distinctly understood that about the end of April, 1881, the contractor must take up each of the pumps, carefully arrange the engine works, and in each case place the whole of the equipment in such a position on the banks of the canal that it can be readily removed.

Nevertheless, if the contractor is able to show to the full satisfaction of the Department of Railways and Canals that he either has or can procure equally as good or a better equipment for pumping and have it fitted up at the respective places by the time it is required, then the renting or leasing of the pumps, etc., at present on the section may not be insisted upon.

As previously stated, the former contractor, under special arrangements with his workmen, delivered a considerable quantity of prepared materials for the piers, abutments and protection works, etc., of the bridge to be built on this section.

The materials and rates paid for them are as follows :—

Dressed stone, 711 cubic yards at $9.00 per cubic yard.....	$6,399.00
Undressed stone, 267 " " $5.00 " "	1,335.00
Sand for mortar	300.00
Timber for protection crib work, cheaply framed, 33,000 lineal feet at 14c. per foot...	4,620.00
Iron rag-bolts, etc., for crib work, 10,000lbs. at 5c. per lb...	500.00
	$13,154.00

It may here be stated that neither the coping stones for the piers, etc., nor the caps for the approaches are delivered in the vicinity of the works and therefore are not alluded to in the foregoing statement.

Parties intending to tender for the execution and completion of the works are specially requested to examine the materials for themselves, inasmuch as they must be assumed by the party whose offer is accepted and at the rates above stated, which, in the aggregate, amount to $13,154.

It should at the same time be borne in mind that the workmanship of the bridge piers and abutments as well as the protection crib work, etc., must be respectively of the class described in the foregoing specification. To ensure this any change or alteration required to be made to any of the stones or any of the timbers to make them suitable for the work must be done by the contractor and be embraced in the prices stated in the "tender" for the completion of the respective works.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the rock or other excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel when passing through the canal may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Railways and Canals and must be executed agreebly to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed drawings, arranged, modified and adapted to the circumstances and the locality and for all such parts of the structures as may be considered necessary for the full understanding of the design will be furnished as the works proceed.

If any alterations be rendered necessary by any cause or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials or for the erection of sheds, store-houses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials other than those before enumerated, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Railways and Canals that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 20th day of April, 1881.

JOHN PAGE,
Chief Engineer of Canals.

OTTAWA, 3rd November, 1879.

APPENDIX No. 24.

WELLAND CANAL.

SPECIFICATION of the Work to be done on SECTION No. THIRTY FIVE of the Enlargement.

This section is wholly within the Corporation of the Village of Port Colborne, extending from the centre of Killaly Street to the south side of Charlotte Street, a distance of about 2,350 feet.

The works to be done upon it include the widening and deepening of the present canal for a distance of fully one-third of a mile; constructing a new entrance lock to and from the harbor, the wings of which at both ends are to be extended so as to form bridge piers and abutments; cutting a raceway, and building a weir arranged to supply part of the volume of water required for the enlarged canal; constructing road bridges; grading towing path and roads, and doing such work as herein described, or that may be required.

The channel throughout to be made of a mean width of 124 feet below the assumed low-water line of Lake Erie, and the bottom of the enlargement, as well as that of the old channel, sunk to an uniform depth of four feet below the top of the mitre sills of the present lock.

For the whole length of the section the bottom will be in rock cutting, which varies from 4 to 18 feet in depth. The side slopes in rock excavation are to be one-quarter horizontal to one vertical, and in clay excavation the side slopes are to be two horizontal to one vertical; except that for side walls or at other places specially mentioned, when the slopes are to be made as steep as can be done with safety.

For the greater part of the section the widening will be done chiefly on the east side, and the new lock will be placed to the east of the existing one—the supply race and weir will be on the west side of the canal.

The side lines of the enlarged channel, and the position of the respective structures will, for the most part, correspond with the lines shown in red on the general plan

exhibited. The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width, equally or otherwise, on both sides, as may be subsequently determined; also of altering the position of any or all of the structures either to the right or to the left, or of placing any or all of them either to the south or to the north of that indicated on the plan, or in such other position as may be considered most advantageous for the purposes contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The material excavated from the widening and deeping of that part of the channel between the north end of the section and the line of the Buffalo and Lake Huron Railway can be deposited on the east side of the canal at a distance of from 120 to 400 feet from the centre line of the channel; provided that a considerable part of it is hauled to the rear side of the bank and placed as herein subsequently described. Parties "tendering" should, however, bear in mind that the spoil ground above mentioned is on the opposite side of the canal from that where the principal part of the excavation has to be done.

The material excavated from the lock-pit and the entrances to it can be deposited to the east of the Welland Railway, within distances varying from 1,200 to 1,500 feet, by raising the spoil banks to a height of from 10 to 12 feet, and forming the rear part of them first.

The material excavated from the raceway and regulating weir can be deposited on the north side of the Buffalo and Lake Huron Railway at from 400 to 1,000 feet from the place where it is removed.

It being clearly and distinctly understood that contractors will not be allowed the use of the present lock to pass scows carrying clay, mud, rock or spoil of any kind from the section, lock-pit or raceway, tenders for the "Excavation" will therefore be received in two different forms, as follows :—

1st. On the understanding that spoil ground for all the material excavated on the section and works connected with it will be found at the places and within the distances previously stated, *i.e.*, for the widening and deepening of the prism of the canal, foundations of side-walls and for the raceway, the material can be placed between the line of the Buffalo and Lake Huron Railway and the north end of the section; and for that taken from the lock-pit and entrances the deposit ground will also be on canal property, but on the east side of the Welland Railway.

2nd. On the understanding that spoil ground for the material excavated from the lock-pit and entrances will be on canal property situated on the east side of the Welland Railway, and that the material excavated from the raceway will be placed on canal property lying north of the Buffalo and Lake Huron Railway; but for all such material as excavated from the prism of the canal for foundations of side-walls, bridge abutments, etc., as may not be required for making up banks, roads or otherwise by the Department of Public Works, the contractor shall, *at his own cost and expense*, find spoil ground.

Contractors are requested to bear in mind that whichever of these offers is accepted it embraces the full and distinct understanding that, where the road on the east side of the canal is likely to be cut away, either in part or as a whole, the contractor must first provide a satisfactory way for the public travel to pass freely and safely, by levelling up

or cutting down the tops of spoil banks, or whatever is necessary to effect the object, all of which must be embraced in the price tendered for excavation.

TOWING PATHS—to be formed on both sides of the canal, the front edges of which will be about 66½ feet from the centre line of the channel; they are to be made 15 feet wide on top, and have an inclination outwards of about 12 inches, to a ditch formed at all places where the natural bank in rear of it is of greater height or opposite where an embankment is to be made. The ditch to be two feet wide at bottom and have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

In connection with them, where necessary, wells are to be sunk, from which off-take drains or culverts are to be made with such a declivity as will discharge the water freely into the back ditch, or where this is found impracticable, into the canal, two feet or more below the assumed level of Lake Erie. These wells are to be from two to three feet square and the culverts from them from 15 to 24 inches square; they are to be built of rubble masonry laid in cement mortar; the bottom of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least six inches under the walls on both sides; the covering of the culverts must be of flat stones of a length which will bear at least six inches on the side walls. The wells and channels from them may, however, be formed of timber and plank, and a bridge be made over the outlet, if so directed. In either case, the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When either the east or west banks are cut into, at any place where they pass through or are immediately alongside of low ground, a new bank must be formed, or an additional width given to the present one, as circumstances may require. In all such cases the space to be occupied by the bank must be cleared of all stumps, roots and logs; all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the bank, as well as between the new banks and seats prepared for them.

BACK DITCHES,—to carry off all the surface water it may be necessary to provide for, are to be formed on both sides of the canal at the places and of the dimensions required; otherwise, that the present ditches are to be thoroughly cleared out and care taken that the drainage is not in any way interrupted. For any drainage that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

The material in the present spoil banks, as well as that at other places above the water surface, which has to be removed at the north end of the section, must be hauled and deposited at such a distance back from the water line as will admit of placing all the rock excavated from the prism at that place on the west bank in the manner herein described.

It will be observed from the position of the work, that the clay portion of it under the water surface connected with the widening and deepening of the channel can be done by machinery during summer months, provided proper precautions are taken to guard against interfering with the navigation; contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be fully prepared to excavate, haul, transport and elevate the material in such a manner as will enable it to be expeditiously removed and deposited at the places and in the manner required, unless

they are able to show to the satisfaction of the Department of Public Works that they are in a position to execute the work in some other way in a more expeditious manner, within the time agreed upon for its completion.

When proceeding with the works connected with the widening and deepening of the channel under the water line, great care must be taken not to cut into the inside slopes or to do anything at all likely to have a tendency to impair the stability of the banks.

SIDES AND BOTTOM.—The canal, as before stated, is to have a mean width of 12[illegible] feet, or a sectional area of 1,860 square feet, through both rock and clay excavation below the assumed low-water line of Lake Erie. The side slopes must in all cases be trimmed off fairly and smoothly to the respective inclinations required, which in rock will be one-quarter horizontal to one vertical, except in the vicinity of structures, when the slopes are to vary so as to correspond at one end with the face line of the rock and at the other end with the wall. In clay excavation the slopes are to be two horizontal to one vertical; but when preparing the seats for side walls or at other places mentioned, slopes varying between one-half and one horizontal to one vertical will be allowed.

The contractor must invariably be guided by the lines marked out by the officer in charge, and see that all angular and prominent points of rock are broken off, so that no part, in any direction, shall project inside of these lines. It should also be borne in mind that in case of there being any protruding or projectional points of rock on the inner face of either side, within the limits of the section, they must be broken off and removed in like manner as provided for those on the side where the principal part of the widening and deepening is to be done.

For the entire length of the section and width of the channel the bottom must be sunk to an uniform depth of four feet below the mitre sills of the present lock at Port Colborne, or to a greater depth if rendered necessary by the inclination or thickness of the lower stratum of rock that has to be removed.

SPOIL BANKS.—From the place to be occupied by spoil banks, all logs and brushwood must be removed or burned, care being taken, however, to guard fully against damaging or interfering with the adjoining property.

In the vicinity of the works, they are in no case to be formed on ground where the surface inclines toward the canal unless level benches are first cut to form a foundation for them. If formed adjoining the canal, on the nature of the seat for them must, in a great measure, depend their actual position and height. It is, however, intended that if placed on the west of the channel their eastern side shall be from 100 to 130 feet west of the centre line; but where rock is near the surface, or the material over it is of a hard nature, the spoil bank may be from 90 to 100 feet back from the centre line. To enable this to be done, the contractor will be called upon, if necessary, to form a level bench from 12 to 15 feet in width along the front side, down to solid ground; on this the largest and best shaped stones taken from the excavation are to be piled or placed in a regular manner as the works proceed, in order to keep the other material in position, and from the north end of the section to near the line of the Buffalo and Lake Huron Railway, a similar rough wall will have to be made on the west side of the spoil ground.

The expense of forming the trench above mentioned, together with that of placing the outer stones so as to form a sort of rough wall, must be included in the price tendered for rock excavation.

The spoil banks must, as nearly as circumstances will admit, be made of an uniform height, those formed of clay must generally have a declivity toward the back ditch of about one in twenty, and for the most part be of a regular width.

SIDE WALLS.—Where the surface of the rock is 6 feet or more over the bottom of the canal, the face of the banks above it are to be protected by means of a dry wall built of large-sized, well-shaped stones of the best kind that can be found in the excavation.

They are to be 2 feet wide on the top, increasing downward on the face side at the rate of about 3 inches to the foot, and on the rear side increase at a like rate for the first 5 feet from the top, thence downward the back is to be plumb.

The stones must be properly bonded over and with each other in the heart of the wall as well as on both the front and rear sides, and in every course there must be headers of at least 3 feet depth of bed placed not more than 7 feet apart. The face of the stones must be hammered, scabbled or picked to the batter of the wall, unless they are in regular courses, when offsets corresponding to the batter can be made.

The coping stones to be of the full width of the top of the wall (2 feet), in pieces at least 9 inches thick and not less than 3 feet long.

In rear of the walls, if so directed, a space of about 15 inches in width and for such a depth as may be ordered is to be made up with small stones, quarry waste or gravel, well rammed.

To form a seat for these walls the surface of the rock must be cleaned off or stripped for the full width required and the material removed to the spoil bank, for which the contract rate for excavation on the section, corresponding to the position of the work done, will be allowed.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal, excavation for bridge, lock and entrances to it and that connected with the raceway, etc., will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those portions of the ground to be removed over the water surface, and accurate soundings made—with reference to fixed and permanent bench marks—at short distances apart, along the whole length and breadth of the section. A duplicate copy the cross sections made from these levels and sounding is to remain on record in the office of the Department of Public Works, and another in the office of the Resident Engineer, and from them, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

The seats of the embankments in rear of the lock walls, bridge abutments and raceway must be cleared of all loose stones, gravel, sand, muck or other objectionable material, and be prepared in the manner required, at the time the works are in progress, by the officer in charge, whose approval must be had and obtained before an embankment is commenced. The material must then be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding nine inches in depth at a time; and if the work be done at a dry season of the year, water must be thrown over the bank to assist in consolidating them.

PUDDLE BEDS—when necessary to be made in any of the banks must be carried up at the same time as the banks are formed. They must be made of

the best description of material for that purpose that can be obtained on the section or in its vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut tranversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil banks in widening and deepening the channel, in lock pit, raceway and other cuttings, except absolutely connected "quarry rock" and detached stone or boulders containing one-half of a cubic yard and upward.

The prices tendered for these items to cover the entire cost of removing the material, finishing up the new cut and banks, forming and grading towing paths, cutting ditches, trimming the sides of both the new and old parts of the cut and work to the required angle, bottoming the whole of the section, the lock pit, raceway and works herein described and completing everything connected with the excavation in a satisfactory and workmanlike manner, agreeably to the foregoing specification and the directions of the officer in charge.

But as the price per cubic yard for each class of work will be an average of the whole of that particular class, within certain limits, progress payments will be made *only* according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in manner following, viz :—For rock excavation down to the level of twelve feet above the mitre sills of the present lock at Port Colborne, *two-thirds* of contract price. For rock excavation from a line twelve feet above the lock sills down to present bottom, five-sixths of contract price. For the removal of rock below bottom line of present canal to the full uniform depth required, contract price and proportion of balance, so that when the work shall have been completed the aggregate amount shall be the same as if the whole were calculated at the prices stated in the contract.

During the progress of the works, the different parts of the "earth" excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

Entrance Lock.

This structure is to he placed on the east side of the present lock and be so situated that the longitudinal centre lines through the respective locks will be 74 feet apart opposite the gates at the south end, and 72 feet apart opposite the north gates of the old lock, otherwise the west wall of the new lock is to be placed as close to the east wall of the old one as the bank in rear of it can with safety be removed.

It is to be made 45 feet in width at bottom and 270 feet in length between the respective gates, there being four sets,—two of which head towards the south and two towards the north. The quoins of the two sets at each end of the lock which head in different directions are to be 15 feet apart, and the bottom throughout must be so arranged that the top of the mitre sill shall be 3 feet lower than those in the present lock, and the top of the first course of floor plank be $4\frac{1}{12}$ feet below the same point.

A retaining wall about 100 feet in length must be built in continuation, northward, of the east wall of the present lock, which at its north end will be connected with the west wing wall of the new lock, when both will make one line of wall and be extended

northward 180 feet in detached pieces to form the centre and rest piers for a bridge to carry the track of the Buffalo and Lake Huron Railway.

Arrangements must also be made to extend the southern wing wall sufficiently to form bearings for a swing bridge for general traffic.

All the walls above referred to with the exception of those directly connected with the present navigation are to be commenced at a depth of four and one twelfth ($4\frac{1}{12}$) feet below the top of the mitre sills of the present lock, otherwise the bottom and mitre sills of the new lock as well as the retaining wall and wing walls are respectively to be fully *three feet lower* than those of the lock now in use.

The face work of the new structure and of all the walls above mentioned are to be of the best description of properly-dressed gray limestone, backed up with large-sized, flat-bedded stones of an approved kind, laid throughout in hydraulic cement mortar and placed on a foundation prepared and arranged as herein described.

When the works above mentioned have been completed as described further on in this specification, the excavation of the bottom part of the lock can then be proceeded with in the usual manner. It is to be made of suitable dimensions to admit the side and wing walls and correspond with the lines marked out and the levels given by the officer in charge; great care must, however, be taken not to disturb the narrow bank between the east wall, of the old lock and the pit. On this, the west side, a slope of one-half horizontal to one vertical will be allowed from the surface of the rock upward, and on the east side and ends an allowance of one horizontal to one vertical will in each case be made for a slope from the surface of the rock upward.

Any clay or other material suitable for making up banks that may be found in the lock pit must be taken to some convenient place, piled there and reserved for that purpose, and the balance hauled to the spoil ground on the east side of the Welland Railway.

The pit and foundations for the structures to be made of the requisite dimensions to admit the side walls, recesses, wings, etc., and to correspond with the lines marked out by the person in charge. For the lower or rock portions of the pit the sides are to be made perpendicular and such a space left for concrete in rear of the walls as the nature of the rock and circumstances may require.

The bottom is to be sunk to the depth of $5\frac{1}{2}$ feet below the top of the mitre sills of the present lock, or to a greater depth if necessary; it must be made sufficiently level throughout to form a fair bearing for the foundation timbers, and space allowed for a bed of mortar or concrete to be laid under them.

If solid and suitable rock in thick layers is found at the proper level at the place where the lock is to be built, the chamber, wing and extension walls will be commenced upon it; but if the rock is unsound, or the fissures in it numerous, or the strata be thin, inclined or irregular, a floor of pine timber covered with 3-inch pine plank will be laid at a height to form a bearing surface for the walls.

In the latter case the foundation timbers are to be of pine 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides, but occasionally two timbers may be used to make up the distance, one of which must, however, extend from the rear line of one wall and across the chamber to two feet under the front edge of the wall on the opposite side. If, however, the circumstances will warrant it, the foundation timbers will only be of a length (50 feet) to reach across the chamber and extend $2\frac{1}{2}$ feet under the walls on each side.

They are to be laid 9 inches apart through the chamber, 6 inches apart adjoining the different mitre sill platforms and at both ends of the lock; in every case they must extend at least 2½ feet under the side walls; they are all to be scribed to the rock and placed on a bed of mortar or concrete as circumstances may require.

All the spaces between them, immediately after they are satisfactorily laid, must be filled with concrete, well rammed, and their tops must be dubbed to an uniform surface to afford a fair bearing for the plank.

MITRE SILL PLATFORM.—For each of the four sets of gates, platforms 14 feet in width are to be formed of pine timber 12 inches square and at least 62½ feet in length, so as to extend fully five feet under the side walls, all of which must be counterhewn and well jointed with a plane in a manner to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron tie rods (1½ inches diameter) screwed at both ends, passing horizontally through the platform; each of the three middle tie rods must have double nuts and washers at both ends in order to form a connection with shackle-bolts that pass down into the rock, and be secured at the lower end with fox-wedges, or in such other manner as may be directed.

All the joints between the timbers of the platforms must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight. They are throughout to be laid in full beds of mortar and secured to the rock underneath by means of fox and key-bolts; at the edge on both sides, each of them will be connected with a stop-water timber let into the rock.

STOP-WATER.—If the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide and of sufficient height to form a close joint with the outer timbers of the platform. Before a stop-water is placed in its berth, a piece of duck or canvas well saturated with white lead must be laid for the full length and width of the check; the upper timber must also be embedded in white lead and the whole secured to the rock with fox and key-bolts 1¼ inches diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described are to be placed at the different recess quoins.

FLOORING.—In the recesses and where required, two courses of pine plank are to be laid, the first three inches in thickness and the second two inches thick. They are all to be jointed with a plane and when being laid must be driven up to water-tight joints; every three feet in width in both courses must break joints at least 4 feet, and the upper course in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails 9 inches long and 1½ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid, the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber on alternate sides of the plank.

In case it becomes necessary to lay a timber foundation through the chamber, either as a whole or in part, only one course of flooring plank will be used.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to framed, mortised, tenonned and secured in the manner shewn on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches, checked three inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check three inches deep is to be cut in the lower edge of the mitre sills to receive the ends of the first course of planking. Before they are put together all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths a strip of canvas well saturated with boiling tar is to be placed in the check formed in the platform into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be one inch and a half (1½) diameter, have upset heads, one half of them to be 2 feet 4 inches long and well ragged at the point, the other half to be 3 feet or more in length, fox-wedged, and let into the rock under the platform.

CONCRETE,—when used in the foundations or elsewhere, must consist of an approved class of stone broken to cubes of 1½ inches, thoroughly mixed with fresh ground hydraulic cement and clean, sharp sand in such proportions as the materials and works may render necessary. The cement and sand must be reduced to a thin paste before the stones are put into it, and when the whole shall have been thoroughly incorporated it is to be taken to the place where it is to be used and spread in layers of from 8 to 10 inches in depth and be well beaten down with suitable rammers.

MASONRY.—The side walls of the new lock and extension of the wings, except at the guard gate subsequently described, will be commenced as near to the level of 4 1/12 feet below the top of the mitre sills of the present lock as circumstances will admit, and be carried up to about the same level as the latter or to a height of 24⅔ feet.

The chamber walls are to be 9 feet wide at bottom, with counterforts in rear 6 feet long in line of wall and 3 feet projection, placed not more than 12 feet apart; the recesses are to be 2 feet 8 inches deep at top; walls 10 feet wide at bottom.

In the recesses for the southern set of gates an inner recess six inches deep will be made, extending downward 10 feet below the top of the coping for skeleton gates to be used for keeping the principal gates closed during rough weather at low stages of Lake Erie.

The face of the chamber walls, wing walls and their extensions are throughout to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

As previously stated, the lock and walls connected with it must be built of the best class of approved, sound, durable *gray limestone*, free from seams, drys, shakes, sand-holes and all other defects, and generally of the dimensions herein stated.

The face stones must be of uniform texture and color, laid in regular courses on their natural beds; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom and diminish upward in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the northern end of the division wall, between the locks, to six feet south of the recess quoins of the northern set of gates which head toward the south, and from a point 20 feet south of the road bridge to 6 feet north of the quoins of the recesses for the southern set of gates which head toward the north, the face work is to be of cut stone dressed and laid so that the beds and end joints shall not exceed three-sixteenths of an inch.

The chamber walls between the points above mentioned are to be faced with a good description of coursed boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths of an inch.

CUT STONE—to be neatly dressed and boucharded, made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones when laid may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall and not less than 2 and 3 feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than eleven (11′) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throu ; ut.

When the face stones are over 24 inches in height the depth of bed of the stretchers in the alternate courses must be at least 1½ times their height, and the headers 2¼ times their height; and in all cases the tail of a header must have a width of two-thirds (⅔) the length of its face.

HOLLOW QUOINS—to be alternately headess and stretchers, the former at least 4½ feet face and 5½ feet depth of bed, the latter 5½ feet face and 4½ feet bed in the top courses, increasing in dimensions downwards at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the resident officer after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet, and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled, as shown on the plan; headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be sixteen chain wells in the position indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than two feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at lest two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone when in place shall not exceed three-eighths of an inch.

BACKING—to be of an approved class of large well-shaped stones not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

COPING STONES—of the chamber, recess, and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The hollow-quoin coping must, however, be at least 6½ feet square on top, and 2 feet depth of bed. The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

A dowel 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

CHECKS.—For the reception of stop-water timbers, checks are to be formed on the face sides of the north wing walls and immediately south of the line of the road bridge, two on each side of the channel-way, directly opposite each other at the respective places; they are to be 2 feet apart, 12 inches wide and 18 inches deep at the bottom, and carried up plumb in the rear, so that their depth at the top will be barely 6 inches.

BRIDGE SEAT.—The bridge to carry the general travel over the canal at this place is intended to span the southern entrances to both the old and new locks; to accomplish this without interfering with the working of the gates, the new bridge will be placed thirty-two feet to the south of the present crossing. To form the centre, bearing or turntable pier for it, the west side of the new entrance will be connected by means of cross walls with the east side of the present one, and the whole carried up to the same height as the adjoining walls, covered with coping stones 15 inches in depth and from 4 to 6 feet in width, according to their position, arranged so as to form a circle to support the track for the rollers. They must all be full bedded throughout and dressed so as to lay the joints not exceding one-fourth of an inch, and the top must have a fair surface, be neatly bucharded, and, where required, the outer top arrises must be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed, the middle part of it to be dressed 4 inches higher than the sides; the space between this stone and the outer range of coping must be filled in with stone the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

The ascent from the coping of the side walls at both sides of both ends of the bridge is to be made by means of a flight of steps two feet in width, not exceeding eight inches rise, cut out of the solid, leaving 12 inches on both sides to be taken off to the rake of the steps; treads to be of an uniform width of at least 12 inches.

This raised part of the masonry at both ends of the bridge will be 3½ feet higher than the adjoining walls, and will extend about 7 feet on both sides of the structure. At both places these walls must be curved, recessed and otherwise adapted to the opening and closing sweep of the bridge, as well as to form a seat for it and the toe-rollers when in position.

GUARD GATE.—At about 50 feet lakeward of the south gate-quoins of the lock, a recess is to be made in both of the side walls, as well as in the bottom, for a guard gate. This gate is to be so arranged as to occupy a horizontal position below the bottom of the channel when not in use, and to stand vertically when required to shut off the water. The recesses in the walls are to be one foot at top, made plumb on the face, 20 feet in length, parallel with the channel, and are to have quoins of like dimensions, arranged in a similar manner as described for those connected with the recesses of the lock. In each of them a circular opening 10 inches diameter is to be formed to admit water under the gate; they are to be started in the bottom course of masonry and carried up vertically two feet back from the face of the recess for a height

of about 10 feet above the bottom, then returned horizontally between two courses of stone to the face of the wall.

For 2 feet south and 3 feet north of the vertical lines of the recesses in the side-walls, or for a distance of 25 feet, the bottom is to be sunk 4½ feet lower than that of the channel for at least 3 feet beyond the face lines of the walls on both sides. On the bottom of this horizontal recess, ranges of pine timber of the full length to extend at least 18 inches under the side-walls are to be laid 12 inches apart upon full beds of cement mortar, and the spaces between them filled with concrete.

At the south side of the recess, a wall of timber 2½ feet or more in thickness is to be carried up to the height of the bottom of the channel, and connected with a stop-water timber let into the rock underneath, and secured as described for the stop-waters at the mitre till platforms. The timbers forming this wall must be dressed and jointed with a plane, be fastened to each other horizontally with screw-bolts, and vertically to the rock underneath, with such a number of fox-wedged bolts of 1½-inch iron as may be directed, at the time when this portion of the work is in progress.

At the north or lock side of the recess, a platform of dressed and well-jointed oak timber, of at least five feet in width, is to be laid at a few inches below the bottom level of the channel, the timbers of which are to be secured to each other with three or more bolts 1½ inches diameter passing horizontally through them, the ends of the bolts to have double nuts and washers, and be connected with shackle-bolts passing down into and secured to the rock.

The breast of the recess is also to be of dressed and well-jointed timbers, one height to make up the space between the bottom of the recess and lower side of the platform.

The lower timber of the breast is to be checked to receive the ends of the plank with which the bottom of the recess is to be floored, and the lower timber of the platform is to be checked to receive the ends of the floor plank of the lock recess.

The timber on the south side of the platform must be of the best description of white oak, 18 by 20 inches, and is to have the south upper edge hollowed out for the gate, as shown on plan.

All the timber of the plaform, breast and recess must be of sufficient length to reach across the channel-way and pass at least 18 inches into the walls at both sides.

The space under the platform, and between it and the breast, must be filled with concrete, and everything done to render the whole water-tight.

In the event of it being subsequently determined to form the upper breast of masonry, a large space must be excavated for it, and the wall must be built of large blocks of stone, laid on the top of the recess floor and carried up to within a few inches of the channel-way.

GATE—to be in one piece, built solid of timber, arranged to occupy a horizontal position in the bottom recess when not in use, and to be 16 feet in height when standing vertically.

It is to be 48 feet in length, the bottom or heel piece of it to be of white oak timber 16 x 16 inches and about 50 feet long, one side of which is to be rounded to a radius of 8 inches, to work in the hollow of the horizontal quoin piece previously men-

tioned, and for about one foot at each end of it will be made round, the full size of the timber, to form bearings for the gates.

All the other bars are to be of pine timber, varying from 12 to 16 inches in thickness, and from 9 to 12 inches in depth. They must invariably be of the full length and thickness of the gate, and be accurately dressed and planed to the uniform parallel depths above stated, to form water-tight joints when in place, as well as a fair face on both sides. They are to be put together with dowels $2\frac{1}{2}$ inches diameter and 3 inches long, let in $1\frac{1}{2}$ inches and fitted tightly into the timbers over and under them. The dowels are to be about 3 feet apart and arranged on alternate sides of the centre line of the timber. The bars of the gate are to be fastened together by means of six (6) wrought iron thorough-bolts, each one and a half ($1\frac{1}{2}$) inches diameter, arranged as shown on plan, having nuts and washers at both ends boxed into the bottom and top-pieces.

The gate is to be strengthened by six timbers 10 x 14 inches, placed transversely. These cross timbers and the bars are to be connected by means of wrought iron screw-bolts, seven-eighths ($\frac{7}{8}$) of an inch in diameter, the heads to be upset, and the washers for them to be countersunk and let in flush on the upper side of the gate. In each post there will be 10 bolts, arranged so that, for the first five feet over the platform, they are to be not more than one foot apart, above which they will be from 18 to 24 inches apart.

The gate is to be further stiffened at top by means of a jointed truss of $3\frac{1}{2}$ x $\frac{5}{8}$-inch iron reaching across it; the ends of the truss to be connected with ring-bolts for raising or lowering the gate.

To support the gate when in motion, six tamarac knees of the proper length, the tops of which have been fitted to the curve of the quoin, are to be put in at equal distances apart and fastened to the floor timber of the recess with rag-bolts.

Anchor timbers, to form the upper part of the bearers for the gate, are to be let into checks cut for their reception, and secured with two wrought iron fox-wedged bolts, let into the offsets which form the gate seat.

For the protection of the joint between the gate and horizontal quoin, a double-hinged cover of boiler plate iron is to be placed over it in such a manner as will form a protection, whether the gate is in a vertical or horizontal position. To guard against injury to this cover, or to the gate when open, a bar of 4 x $\frac{5}{8}$-inch wrought iron is to be bolted on to the top of the cross sill over the quoin piece.

The knuckle bars to be $3\frac{1}{2}$ x $\frac{5}{8}$-inch wrought iron, made with three joints, one at the bottom, another near the middle, and a third at the top, each joint to be formed with double claws and made to receive a two-inch pin, without in any way diminishing the full strength of the bar, and arranged to work freely. To form the connection at the upper side, a bolt with a double eye will pass through the third bar from the top and also through a plate of wrought iron which, together with the nut, must be flush with the face side of the gate.

The necessary pulleys and opening chains for the gate must be provided by the contractor.

All the wrought iron used in connection with the gate must be of the best and toughest kind of refined English or Canadian iron; the castings must also be of the best quality, and both the wrought and cast iron work must be prepared and fitted up in the best manner by turning, filing or otherwise, as may be required to ensure the description of work contemplated in the plans and foregoing specification.

The iron work must be heated to such a temperature as may be required, and receive a bath of coal tar or linseed oil before being put in the work.

All the woodwork must be put together with white lead and oil, which must be freely used in every joint and dowel, between the bars, between the binders and bars, at all mortises and tenons and at every place where two surfaces of wood or of wood and iron come in contact.

The north-west wing of the present lock, or as much of it as projects beyond the rear line of the walls of the new one, must be wholly removed to admit of making a water-tight connection between the back of it and a range of concrete to be formed in rear of the east side of the old lock for its entire length and, as far as possible, the walls above it.

The seat for this concrete wall, which is to be 3 feet in width, is to be formed immediately along by the back of the old wall and sunk down to the depth of the stratum of rock on which the walls of the present lock stand, or lower if the rock is not of a sound and compact nature. Great care must be taken to clean the back of the old wall for the whole distance and height, as upon the proper execution of this part of the work will, in great measure, depend the quantity of water that will have to be contended with in the new lock pit.

CENTRE WALL.—The seat for the wall below the present lock and opposite the recess of the new structure is to be sunk to an uniform depth of 4 feet or more below the present mitre sill; if the rock is sound and of a good class the wall will be started upon it, otherwise the depth will be increased and a foundation of timber laid either longitudinally or traversely, as may be subsequently decided, and the space covered with three-inch plank, fastened as described for the lock.

For a distance of 85 feet north of the north quoins of the present lock the side lines of the centre wall will correspond with those of the respective locks, when the thickness will gradually diminish to about 18 feet within a distance of 68 feet, or at a point which forms the rest pier for the movable part of a swing bridge, and will be finished as described for the one at the northern end. The piers and abutments are to be parallel to the line of the canal, built of the width and in the manner herein described.

BUFFALO AND LAKE HURON RAILWAY BRIDGE.

This railway is situated so near the northern end of the lock that the entire channel will have to be spanned by a movable bridge resting on a pier in the middle, thus making the water-way in two divisions, each with a clear opening of at least 63 feet in width at the assumed low-water line of Lake Erie.

The piers and abutments are to be of masonry laid in hydraulic cement mortar, built chiefly in the form, of the dimensions and in the manner herein described, or as may be subsequently directed.

The bridge being situated at a place where the canal is cut through rock, the foundation will be on the same level as the bottom of the reach unless it is found that the nature of the rock renders a greater depth necessary.

The centre pier and the rest pier of the bridge are to be as nearly as possible parallel to the centre line of the canal, the former to be 18 feet square and the northern rest pier 18 feet in width and 10 feet thick at top. Through each of them an arched

culvert 8 feet wide and 8 feet in height is to be made on a line ranging with the water-way.

The abutments are to be commenced either at canal bottom or at such a height above it as warranted by the nature and soundness of the rock, but at whatever height they are started they must occupy such a position that five feet above canal bottom their face lines produced shall not, at any place, be inside the line of the canal. They are to be carried up to a batter of one in twenty-four on the face, and at top offsets are to be made for the bridge seat; the walls are to be 7½ feet or more in thickness at bottom, be made plumb in the rear to within five feet of the top, thence diminish to the rear line of the coping which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized well-shaped stones laid level in full mortar beds and properly bonded throughout the walls.

The top of the abutments to be stepped down at the rate of one in twelve on both sides, with stones not less than 2½ feet width of bed to the level of the coping of the side walls.

The arch stones of the culvert are to be 21 inches deep, dressed to radiate truly for their full depth and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom part of the arch or water-way is to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening, and the end of each pass 12 inches under the wall; the second course to project one foot into the opening on each side, and the third to project inward 6 inches.

The face stones of the piers to be two and three feet depth of bed in alternate courses, with headers in every course 4½ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre, as well as the rest pier; in each case they are to have a batter of one in twenty-four.

The heart of the wall must invariably be made up with flat-bedded stones not less than 4 feet area of bed and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch and the vertical joints be not more than one inch and a quarter.

The centre pier and rest pier of the bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge, and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout, and dressed so as to lay to joints not exceeding one-fourth of an inch; and the top side must have a fair surface, be neatly boucharded and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same

thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones for a width of four feet is to be twenty-four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

CRIB WORK.—Between the centre and rest piers, as well as at the ends, crib work is to be construc.ed to form bearings for the fenders, and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 18 feet wide at top, increasing downwards on both sides at the rate of one in twenty-four, and through the middle of them, longitudinally, a clear water-way of such dimensions as may be directed must be formed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges, and are to be framed so as to leave a space of 1½ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course, a rag-bolt 12 inches long and ⅞-inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends, and the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed 3½ inches into the timbers under and over them, the dovetail to splay 1½ inches on both sides so as to stand eight inches at the neck and 11 inches at the outer end.

Under the head of each tie, in the joint between the courses immediately below it, a block 1½ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt 2½ feet long. ⅞ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it, and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them, and be secured by bolts of similar dimensions in like manner as described for the tranverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails two inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside, and extending from the lowest side timber up to the water-line. There are to be three ranges on a side, that is to say: One at or near each angle, and another in the centre, making in all six vertical ranges in a crib. The planks are to be four inches thick and

10 inches in width, fastened from the inside with 10-inch spikes five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from eight to ten feet or more; but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than three feet apart, so as to obviate the necessity of using floor timbers.

The crib forming the northern termination of the pier is to splay five feet or more on the sides next the channel.

The whole interior of the crib work except the water-ways to be filled with an approved class of moderate-sized stone ballast.

Along both sides of the guide piers there are to be two ranges of wale timbers of white oak 6 x 12 inches; the upper range to be fastened by means of screw-bolts half an inch diameter, having upset heads let into wrought iron washers countersunk for them. The other range to be seven feet lower, and fastened by rag-bolts $\frac{3}{4}$ of an inch diameter, having similar heads and washers to those in the upper range.

The wale pieces to be put on in lengths of from 24 to 40 feet; their upper edges are to be chamfered, and where they connect, their ends are to be scarfed, covered with boiler plate and secured as directed.

For the protection of the structure and piers, three clusters of detached oak timbers are to be placed vertically within range of the centre pier, at suitable distances to the north of it; their ends are to be let into the rock underneath for such a depth as circumstances may require. On the lower end of each timber a band of wrought iron $3\frac{1}{2}'' \times \frac{1}{2}''$ is to be fitted, and a bar of iron 2 inches diameter is to pass vertically 12 inches into the timber and 18 inches into the rock; they are further to be fastened by means of knees, straps and bolts in the most secure manner that their position, etc., will admit of adopting. At the top they are to be connected by means of thorough bolts, straps and otherwise, and stand one foot or more over the cribs, as may be required.

On both sides a range of floating fender timbers is to be constructed on both the north and south sides of the abutments; otherwise, lines of fixed fenders may be placed there and secured by anchor timbers let into the bank, as circumstances may require.

The superstructure of the bridge, both for the fixed and movable parts, as well as the machinery for working the latter, will be made a separate contract.

At the southern entrance the side wall on the west side is to be extended as far beyond the line of the road bridge as circumstances will permit, and on the east side the wall is to be continued until it intersects the present side wall of the basin.

The contractor will be expected to do the greater part, if not all, of this work before the bank is cut through or the water let in, other than such leakage as may reasonably be expected from the position of the works and nature of the material.

The deepening of the channel and part of the basin southward to the end of the section, to 4 feet below the top of the mitre sill, the lower or bottom part of which is through rock, it is believed can be done by under-water blasting; parties tendering will therefore be expected to state the rate per cubic yard for which they would be

willing to do the work in this way; the quantity removed to be ascertained from soundings, etc., as previously described for other parts of the section.

When the channel and adjoining part of the basin have been sunk to the depth stated, a rest pier for the road bridge is to be constructed of crib work in like manner as described for work of that class for the northern end of the railway bridge.

Supply Race, etc.

For the purpose of admitting and regulating part of the supply of water required for the canal, a raceway will be formed on the west side of the present entrance lock, which will occupy the entire space between it and the west side of the adjoining street. It will connect with the basin at a point immediately above the lock and be continued northward until it enters the canal between the line of the Buffalo and Lake Huron Railway Bridge and the north end of the guard-lock, as represented in red on the general plan exhibited.

The space above mentioned is to be sunk to the full depth of the mitre sills of the lock, and will be divided into two channels, the eastern one of which will be open, and the other one, or the part situated on the land now used as a street, will be arched over to the extent indicated, in such a manner that it can be again used for that purpose.

The eastern haunch of the arch, or at least the outer part of it, will be carried up to the level of the street, and a railing put up along that side for the safety of the public. The regulating gates will be situated near the place where the raceway enters the canal, and north-west of the guard-lock.

Excavation.—The material excavated from the raceway is to be deposited on the north side of the Buffalo and Lake Huron Railway, within the distances and in the manner previously stated.

The lower part of the excavation will be in rock, which must throughout be sunk to the full depth of the mitre sills of the present lock.

The sides of the cut through rock are to have an inclination of from one-twelfth to one-quarter horizontal to one vertical, as may be required or warranted by the nature of the material.

There will be allowed on the west side a slope of one horizontal to one vertical, and adjoining the lock a slope of one-half horizontal to one vertical; in both cases this applies only to material excavated above the surface of the rock.

The contractor will be required to do the principal part of the excavation for the raceway in short stretches, and throughout must conduct the work in such a manner as not to incommode the public but as little as the circumstances will admit. When removing rock, as little powder or other explosives is to be used as the work can be done with efficiently, and the blasts must invariably be properly covered up to prevent the materials from spreading. For any damage done to adjoining property, by neglecting to carry out this essential condition, the contractor will be held strictly and, in every respect, legally liable to adjoining proprietors for any injury or damage they may sustain from any of his acts in connection with the prosecution of the work.

Contractors, when tendering, should bear in mind that the above condition relative to covering blasts, etc., and the responsibility of the contractor to adjoining proprietors

and the public, for loss or damages sustained, are applicable to the whole of the excavation on the section, including lock pit, entrances and raceway.

In rear of the west wall of the lock, from the surface of the rock or for a greater depth if required, a wall of concrete is to be carried up, and every precaution taken to form it in like manner as described for that on the east side of the east wall of the lock, the object being in both cases the same, *i.e.*, to guard as much as possible against leakage.

MASONRY.—The side walls of both divisions of the raceway are to be of coursed masonry, which, together with the arch over the western side, are to be laid throughout in hydraulic cement mortar.

The covered division of the water-way is to be 25 feet in width; abutments to be carried up plumb for 7½ feet on the springing line of the arch, which is to be a semi-circle of 12½ feet rise.

The western abutment is to be 7 feet wide at bottom, and will be carried up plumb on the rear side to within 4 feet of the crown of the arch.

The middle pier, or that which forms the east abutment of the archway, is to be 8 feet in width at bottom, and its east side is to be carried up to a batter of two inches to the foot rise, to within six inches of the crown of the roadway to be formed over the arch; and on the rear side a frost batter of three inches to the foot is to be formed for four feet below the top.

On the east side of the open water-way, which is to be about 32 feet wide at bottom, the wall is to be 7½ feet wide at the foundation, and have a batter on the face of two inches to the foot rise up to the top of the coping, which is to be 3 feet wide on top, and placed at the same level as that of the lock.

The face stones of the side walls and abutments must be at least 20 and 30 inches depth of bed in alternate courses, all of which must have not less than 2 feet length of face, and have headers in every course of at least 2 feet length of face and 3½ feet depth of bed, placed not more than 12 feet apart from centre to centre.

The face of the stones must be picked, pointed or scabbled to suit the batter of the wall and the position they are to occupy in the work. Their end joints must be squared or kept full for a distance of nine inches back from the face, and all prominent or projecting points must be dressed off both beds of the stones of every course, which throughout must be of equal height and laid in such a manner that neither the horizontal nor vertical joints shall exceed half (½) an inch.

BACKING.—All the backing-stones used in the walls must be of an approved class of large well-shaped stones, not less than six inches in thickness and three feet area of bed, laid level in full mortar beds and properly bonded throughout the wall. Their lower beds, if necessary to make satisfactory work, must be picked off so as to give a fair and equal bearing on the course below; thin wedge-shaped edges of stones must, in all cases, be broken off to not less than six inches thick.

The backing-stones must in all cases be laid on their broadest beds, and the stone opposite a face header must occasionally extend to the rear line of the wall.

The courses of the abutments must be arranged to terminate at the springing line of the arch, and the width of the bed of the stone at that line must be at least 2 feet 9 inches in width.

The arch stones must be fully two feet depth and be at least ten inches thick on the soffit, which must be dressed to correspond to the line of the curve, and the beds be dressed smooth and straight, and so as to radiate truly for their full length (2 feet); their end joints must also be kept full throughout, and the various courses must be of such lengths as to break joints at least 12 inches over and with each other. The courses must be divided in such a manner that there shall be an equal number on each side of the key-stones, which must be at least ten inches thick on the lower side or soffit when fitted for the respective places they are to occupy. The stones which form the arch must be dressed in such a manner that when laid in full mortar, and fully driven up with a heavy wooden maul, the joints shall at no place exceed one-fourth of an inch.

At both ends of the archway, the heads of the ring-stones are to be dressed, and, if required, must project one inch and a quarter beyond the general line of the wall. They are to be jointed to such lines as will admit of forming suitable connections with the face stones of the haunch of the arch, and at the joints they are to be chamfered.

Parties tendering should bear in mind that the raceway, at its southern end, must unadvoidably be slightly curved, especially the western or arched portion of it, and that all expenses connected with which must be included in the price tendered for raceway masonry.

It is also proper to state that recesses are to be formed in the face of the east and west walls of the open raceway for girders for a roadway across it, either directly opposite the swing bridge or at such other place as may be pointed out when the works are in progress.

The coping stones on both sides of the raceway must be 3 feet in width on top and at least 12 inches in thickness. They must be dressed throughout so as to lay to joints not exceeding one-fourth of an inch; their upper side and faces must be neatly boucharded; those on the west wall are to project four inches, and the rear part of all of them must correspond with the frost batter.

The western abutment wall is to be continued round to form the side of the basin above the regulating weir, as indicated on plan. Immediately at the outer end of the arch this wall will be plumb; but the face will gradually wind round until at ten feet from that point the batter on the wall will be two inches to the foot rise.

This batter is to be continued to within 10 feet of the north-west end of the regulating weir, when the batter will diminish, until at the point mentioned it is not more than one in twenty-four. The whole of this wall, as well as that on the east side, up to the south-east end of the wall connected with the weir, will be estimated and paid for as raceway masonry.

The wall at the north end of the present lock on the channel side, which connects with the supply weir, will be measured and paid for as weir masonry.

Parties tendering should bear in mind that the raceway, at its southern end, must unadvoidably be curved toward the south-east, especially the western or arched portion of it; this work, together with all the masonry connected with the south end of the wall between the lock and the supply channel, as well as all other work to be done between the inner harbor or basin and the south-west line of the regulating weir, will be estimated and paid for as earth or rock excavation, or raceway masonry, according to the class of work done at the respective rates stated in the tender for these items.

The arches are to be formed on properly-framed centers of sound, moderately-well seasoned, suitable timber, and must be of approved construction, securely and satisfactorily braced and fitted up. They must be supported on slack blocks, such as will admit of their being gradually lowered at least six inches.

As previously stated, the raceway, especially the western or covered side of it, is to be formed in short stretches at a time, so that not more than 100 feet of centering will be required and probably much less.

The cost of all materials and workmanship connected with the construction of centers, fitting them up and their removal, and again fitting them up as often as may be required, or of providing others in their stead, or whatever may be required for the full and satisfactory completion of the raceway must all be embraced in the rate tendered for raceway masonry.

On the top of the arch, a road-way is to be formed by material from the excavation, about 30 feet in width of it is to be macadamized for an average depth of 12 inches with an approved class of stone broken to cubes of such dimensions that every piece in its greatest length could pass through a ring two inches diameter.

The macadamizing to be properly shouldered up, and a water table of pitched stone, 10 inches deep, formed on the west side, with such an inclination as will carry off the surface water either to the south or north end, as may be directed.

SUPPLY WEIR—to be constructed at the north end of the raceway in the position indicated on the general plan, the side walls and piers of which are to be of masonry, and between them are to be movable bulk heads arranged as herein described.

The side walls are to be built of stones two and three feet depth of bed, in alternate courses, with headers in each course 4½ feet deep and not more than 9 feet apart; all of them, as well as the piers, must be dressed to a batter of one in twenty-four, and the beds and ends made so that the horizontal and vertical joints between the stones when in place shall not exceed one-fourth of an inch.

There are to be four piers, each 5½ feet at top, placed 17 feet apart, and the same distance from the side walls at assumed low-water line. The piers are to be 30 feet in length, be slightly pointed at the lower ends; they are to be made up alternately of two and three stones in width, except in the vicinity of the recess subsequently mentioned, where for about half the length of the piers, the upper eight feet in height must be made up of two stones in width, one range of which in each course must extend six inches beyond the centre on alternate sides.

In other respects the masonry of the weir is to be of a like class as that described for the cut stone work of the locks.

At about 3 feet from the upper end of the pier, a recess 9 inches in depth and for a width of 4 feet is to be made in both sides of the face of each pier and in the face of the abutments, for movable bulkheads.

At 12 inches below the assumed low-water level of Lake Erie, checks 12 x 12 inches are to be made alongside of the recess and carried up to the full height of the walls for the reception of stop logs.

All the coping stones to be of the full width of the piers.

To form a bearing for the lower part of the bulkheads, a platform consisting of three or more timbers is to be laid in all the five openings and pass at least one foot at each end under the side walls; the timbers must be jointed with a plane, scribed to the rock underneath, be drawn close together by means of two horizontal screw-bolts one inch and a quarter diameter, and secured to the rock by two or more fox-wedged bolts in each timber, of such length as the circumstances may require.

The bulkheads are each to be about 18 feet in length, 12 feet high and 3 feet wide; they are to be divided by vertical timbers into three openings each 5 feet in width. The upper 6 feet is to form a caisson with three chambers, built chiefly of white oak scantling varying from 4½ to 6 inches thick. In the lower part of the bulkhead there are to be three sluice-gates, each five feet square.

All the timber of the bulkhead must be carefully dressed, fitted and put together with white lead so as to make water-tight joints; when in place they are to be secured both vertically and horizontally by tie rods from ¾″ to 1″ diameter, according to the place where they are situated; each tie rod to have proper nuts and washers at both ends.

At both ends of the caisson, a post 14″ x 6″ is to be fastened with screw-bolts, of a length that when the bulkhead is in place the posts will stand 15 inches or more over a foot bridge resting on the piers, and be doubled-tenonned into a timber 6″ x 14″ intended to carry the ends of the rods for working the valves, whether they are made to slide or turn on a pivot. This bridge timber is to be stiffened by diagonal braces at the corners.

If the gates are to turn on a pivot, there will be three gates for each opening between the piers, or in all 15 gates and turning rods, but if sliding gates are adopted there will be only one gate for each opening between the piers. As a means of raising and lowering the gates, a rod will be attached at both ends of them near the recesses in the walls, which will work through a brass matrix fitted into castings secured to the gate, and the upper ends of the rods are to have bevel spur wheels keyed on to them, to gear into pinions on crank shafts attached to the bridge.

Provision is also to be made for raising the caisson at periods of low water in the lake; for this purpose a similar arrangement of screw rods and gear to that above described must be made and fitted, if directed.

In the checks cut in the masonry over the top of the caisson, stop logs are to be fitted to form a breast wall suited to the fluctuations of the lake level, the lowest of which is to be 12 x 14 inches, and when in place must be fastened by wedges or otherwise, if directed.

The foot bridge is to be 3½ feet or more in width, formed of pine timbers 12 inches square, laid 2 inches apart, and fastened to the coping of the side walls and piers with fox-wedged bolts of the length and in the manner directed.

If considered necessary a two-ply boom two feet in width must be made and placed so as to extend from the abutment of the Buffalo and Lake Huron Railway bridge across the outlet from the supply race.

Temporary Bridges.—It is to be clearly and distinctly understood that the contractor shall provide, fit up and maintain, at his own cost and expense, a satisfactory and safe means for the public travel to cross the cut for the raceway, also the pit for the lock during the whole time the works are in progress, and that he will be held strictly and legally liable for keeping these crossings in such a condition

that they will be easily accessible and can be safely used by the public—for the bulk sum stated in the tender for these purposes.

MORTAR.—The whole masonry of the lock and extension walls at both ends of it; bridge piers and abutments, the raceway and supply weir, must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout to be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half (1½) of clean, sharp sand to one of cement, and adding as much mortar as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stone and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of the frost.

ORDER OF BUILDING.—The lock and side walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones for all the walls must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

From the foundation up to the top of the rock, the spaces between the walls and sides of cut are to be filled with concrete, or so much of them as may be directed.

PUDDLE BED—in rear of the lock walls to be 3 feet in width carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds, where required at other places, are to be made in a similar way and of such dimensions as may be directed. The embankments at the back of the walls to be made up in the

manner before described, and all such ditches made as may be required to carry off the surface water.

The superstructure of the swing bridge and the machinery required for working it, as well as the lock gates, will be made separate contracts; but all the masonry required to be done on the section is to be built by the contractor for the lock.

Immediately after the works have been awarded and a contract entered into with the person whose tender has been accepted, the contractor will be called upon to proceed with the excavation connected with the widening of the channel-way down as low as the water in the canal will admit. He must also make all such arrangements as will enable the widening and deepening below the water level to be commenced and vigorously carried on as soon as the season of navigation this year (1877) is closed.

To accomplish this object the contractor must provide and deliver in the vicinity of the works all necessary derricks, drilling machines, pumps, equipments for coffer dams, plants and tools required to urge forward the operations in an energetic manner, to the full satisfaction of the Department of Public Works and its officers.

Contractors should bear in mind that the retaining wall at the north end of the locks, including the southern rest pier for the railway bridge, should be built and the concrete walls on both sides of the present lock put in between the close of navigation of the present year (1877) and the opening of the canal in the spring of 1878.

For the purpose of enabling these works to be done, the widening and deepening of the channel to be proceeded with, side walls to be built for the protection banks, and other works on the section to be urged forward, the water will be shut off at the lock and at the outlet of the Feeder, and the canal will be emptied, as nearly as circumstances will permit, in the early part of December, 1877, and the water will be allowed to remain out until in April, 1878.

The contractor's arrangements for proceeding with the works must therefore be such that every possible advantage will be taken of the time above mentioned to urge them forward in an energetic and satisfactory manner.

Contractors are, however, distinctly informed that shutting off the water at the places above mentioned, and the drawing of it off at Port Robinson will not have the effect of laying the bottom of the canal dry; several feet of water will still remain in it.

This unavoidable state of matters should be borne in mind by contractors when tendering, as well as the fact that the only possible way of getting rid of the water is by pumping, and moving part of it when frozen.

Under any circumstances a dam must be made at the north end of the section to prevent the water coming from or passing on to Section No. 34, and another dam must be made to thoroughly prevent water from Lake Erie entering the present lock at Port Colborne.

If the contractor is prepared to show that he will adopt all satisfactory and necessary precautions to effect the latter object without endangering existing works, he may be allowed to shut off the water at the lock gates. For this purpose he (the contractor) must provide tarpaulings sufficiently large to cover the whole surface of either south or north pair of gates, which head towards the lake, and extend several feet along the sides of the recesses and bottom at the place where they are used, in order that as little clay as possible may be required to form a staunch dam.

It is probable that the winters of 1878 and 1879, or the period between the closing of the canal in December, 1878, and the opening of navigation in the spring of 1879, will also be required for the execution of the work on this section. Contractors are, however, hereby distinctly informed that for the period mentioned, *i.e.*, between December, 1878, and April, 1879, the water level north of Port Colborne will not be drawn down lower than the level of Lake Erie.

This will necessitate the construction of a high dam at the north end of the section, staunching the lock gates in the manner above stated, and pumping out the entire quantity of water between these dams. For this the contractor is expected to state a bulk sum in the tender, which must include the construction and maintenance of the dams during the winter, and their entire removal by the time required in April following.

Further, if required, the contractor must again put in a high dam at the north end of the section, staunching the lock gates in the manner previously stated, in December, 1879, maintain them during that winter and remove them in April, 1880, all of which, together with the unwatering of the works on the section for the period stated, (from early in December, 1879, until in April, 1880), must be included in the bulk sum stated for these purposes in the tender.

If it, however, be decided to shut off the water at Port Colborne and at the outlet of the Feeder in the month of December, 1878, and to draw off the water at Port Robinson and to allow it to remain out of the canal until in April, 1879, contractors are requested to bear in mind that the Department of Public Works reserves the right of paying only a like sum for these purposes as stated in the accepted tender for dams and their removal, together with the unwatering of the section for the period from the early part of December, 1877, until in April, 1878.

When preparing their tenders, contractors should bear in mind that the respective bulk sums for unwatering the different parts of the works at the different times stated, must in each case embrace the construction of all dams, their full maintenance, and their removal at the time directed; also the providing and fitting up of all pumps and machinery that may be required for that purpose, together with the removal of all snow and ice; and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundation of all structures on or connected with the section, must all be included in the respective bulk sums stated in the tender.

Contractors should clearly and distinctly understand that all the works connected with building the new piers and abutments for the Buffalo and Lake Huron Railway Bridge, as well as those for the enlargement of the canal at that place, must be done without in any way or shape interfering with the railway traffic. The carrying out of these conditions will be rigidly insisted upon, a fact which should be borne in mind by parties when tendering for the work, and also that the contractor will be held strictly and legally liable to the proprietors of the railway, the public or individuals for any loss, damage, accident or detention which may be sustained through his acts, whether the same arise from oversight, neglect or from a desire to proceed with the works expeditiously, or from any other act or cause whatever.

The removal of the present pier and abutments of the railway bridge is to be tendered for by the cubic yard, the rate to include the removal of all mason work, crib work, piles or whatever may be necessary to clear out the channel to the required capacity; these works must be proceeded with at the time directed by the Department of Public Works.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the rock or other excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, and must be executed agreeably to the plan contemplated in this specification, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction; but detailed drawings, arranged, modified and adapted to the circumstances and the locality, and for all such parts of the structures as may be considered necessary for the full understanding of the design will be furnished as the works proceed.

If any alterations be rendered necessary by any cause, or for the benefit of the works, the contractor, if directed, must carry them out in like manner as if they formed a part of the original design, and at a rate or price fixed by an authorized officer for the additional or reduced expense that may be caused by the alterations.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing or preparing of materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the officer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the department of Public Works that the whole of the works described in the foregoing specification and embraced in the contract can be fully completed on or before the 20th day of June, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 17th July, 1877.

APPENDIX No. 25.

WELLAND CANAL.

SPECIFICATION for the Enlargement and Deepening of PORT COLBORNE HARBOR, Construction of Pier Work, etc., etc.; SECTION No. THIRTY SIX.

The works to be done on this section are chiefly the extension of the west pier about 400 feet further into the lake; deepening the entrance channel from the lake inward; rebuilding the superstructure of part of the west pier and the whole of that on the east side; constructing a beacon on the south-east side of the entrance, (near the place where a buoy is at present moored) and building four detached blocks of pier work between it and the outer end of the present east pier; removing and rebuilding about 700 feet of the west docking, from the ferry recess outward; deepening the basin and enlarging it to the extent represented on the plan, and such other works as are herein described.

The channel, from the lake northward to about the southern line of the contemplated enlargement of the basin, is to be sunk to a depth of five feet below the top of the present mitre sill of the entrance lock. From the latter place to the lock the depth will gradually diminish to about four feet below the top of the lock sill.

The side lines of the basin, together with those laid out for its extension, are to be maintained, and the respective range lines of the west pier outward will be continued, as well as that of the outer portion of the pier on the east side.

The southern boundary of the section is the line of 17 feet of water in the lakes at a time when it stands 12 feet over the mitre sill of the present lock; and the south side of Charlotte Street, near the lock, may be considered as its northern end. It should, however, be clearly understood that the Department of Public Works reserves to itself the right of determining at any time on or before the first day of November, 1876, at what point or place in the basin the northern boundary shall terminate.

This condition, it should be borne in mind, may be enforced, although the contractor may have done work to the north of the line before a decision is arrived at, without giving cause for any claim for compensation, other than for the actual quantity of work done at the respective rates stated in the tender.

Contractors have an opportunity of trying or examining for themselves the nature of the material to be removed from the bottom of the channel and basin ; still it may be stated for their information that, in both cases, it embraces two kinds of work, one of which can be executed by means of an ordinary dredging machine ; but the other consists of a hard class of rock, with numerous nodules of flint interspersed. The depth of water over the rock alongside of the west pier is from 9½ to 10½ feet, increasing toward the east at the rate of about one in fifty. At the north-west side of the basin, at about the level of the rock sill, there is rock with a dip of nearly one in fifty toward the south-west.

Attention is drawn to these important matters at this time so that contractors may look carefully into them, and with a knowledge of the facts be enabled to determine for themselves the value of the work to be done.

For a width of 400 feet at the outer end, the channel is to be made of the depth above stated (5 feet below the top of the present lock sill), thence inward the width will diminish to 150 feet at the narrowest part, or adjoining the south end of the extension of the basin. At all places the deepening is to be continued up to within 15 feet of the side lines of the respective piers, and wherever the cuttings exceed a depth of two feet, the sides must be taken off as nearly as possible to an uniform slope of one to one, or to such other angle that the top line of the cut cannot in any way impede the passage of vessels, even when they are nearly close to the pier.

When the work of deepening the channel through rock is in progress, the material, after it has been loosened by blasting or otherwise, must be removed as rapidly as possible, especially if any part of the rock is forced up higher than the present bottom.

To be certain of this course being strictly carried out, no more material is to be loosened by blasting on any one day, during the season of the navigation, than the contractor has the means of removing the same day, to a depth of at least that of the adjoining portion of the bottom. Similar precautions must be adopted where the cutting in the basin is rock.

All dredging operations, whether in the channel or basin, must be conducted in such a manner as to occupy at all times the least possible width, but especially when there are many vessels entering or leaving the canal. At such times the deepening of the narrow part of the channel is not to be proceeded with, and at other places arrangements must be made to have the dumping scows on the opposite side of the dredging machine to that on which the vessels are to pass.

The enlargement of the basin has so far advanced that a wall along the east side of it has been built ; but with the exception of one crib, a line of pier work has still to be formed across its south end, to connect with that of the present line. To the north of the outer angle thus formed, the old pier, for a distance of about 650 feet, must be removed down to the depth previously stated.

The present docking or pier on the west side, from the ferry recess outward, having settled so much on the front side as to render it insecure, about 700 feet of it must be removed, and at the same time a seat for a new line must be formed at a depth of fully six feet below the lock sill.

The removal of this part of the old work is not, however, to be proceeded with until after the contractor has furnished and delivered in the vicinity such a quantity of suitable timber as may be required for the new docking.

The material excavated, dredged or taken out for the deepening of the entrance to the harbor, or for the enlargement and deepening of the basin, or the removal of the old pier work, must all be taken out into the lake in scows and dumped as close to the shore as possible beyond the first point, about one mile east of the entrance piers, or at such other places beyond the line of six fathoms of water as may be directed.

It is to be clearly and distinctly understood that all the excavation or dredging done towards deepening the entrance channel, deepening and enlarging the basin through rock and all other material, also the removal of the pier work on the east and west sides of the channel, will be measured, computed and paid for in the "solid." For this purpose accurate levels and soundings will be taken over the whole area to be deepened in the channel and basin, before the works are commenced, and referred to a fixed and permanent bench mark. Duplicate copies of the sections made from these soundings will be prepared, one of which will be placed on record in the office of the Department of Public Works, and the other will remain in the office of the Resident Engineer. From these documents, after it has been fully ascertained that the different places have been excavated, dredged or otherwise sunk to the respective depths contemplated, the items of work done and for which the contractor is entitled to be paid, will be computed.

Extension of West Pier.

The west pier is to be carried 400 feet further into the lake, and there terminate in a square 60 x 60 feet, inside of which, to the end of the present pier, the width will be 30 feet, and the whole will be formed of crib work up to about the surface of low water.

Crib Work—to be of the full width above stated and in lengths of at least 30 feet. The sides and ends to be of timbers not less than 11 inches square, straight, sound and full on the edges, carried up vertically to within two feet of the water surface, where a batter of one in twelve is to be commenced on both the front and rear sides.

Framing.—The outer timbers of the cribs are to be framed so as to leave a space of 2 inches between the different courses, and at the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends.

At each corner in every course a rag-bolt 12 inches long and five-eighths ($\frac{5}{8}$) of an inch diameter is to be driven through the dovetail.

Cross Ties—to be at least 10 inches thick, of sufficient size to square 10 x 11 inches at both ends, and of the full length of the outside width of the different cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie at the joint between the courses immediately below it a block 1 x 11 x 11 inches is to be inserted to give an uniform bearing, and a rag-bolt 2½ feet long, seven-eighths (⅞) of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and four inches into the head of the next cross tie.

LONGITUDINAL TIES.—In all the cribs, longitudinal ties 10 inches thick are to be framed into and dovetailed between the alternate tiers of end timbers, have blocks under them and be secured by bolts of similar dimensions and in like manner as described for the transverse ties into which they are to be notched and fastened at the crossings by means of white oak treenails 2 inches diameter and 16 inches long.

In the cribs forming the terminations of the pier there must be longitudinal ties in every course placed alternately 10 feet and 20 feet from the face side.

The cribs are to be further secured by vertical ranges of binders placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: One at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spikes five-eighths (⅝) of an inch diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the floor upwards. They may be put on in lengths of from 8 to 10 feet or more, but they must be so arranged that the upper lengths in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

BALLAST FLOORS—to consist of flattened timbers 10 inches in thickness and of the full length of the width of the respective cribs. They are to be laid transversely from five to six inches apart and rest on either the first or second course of side timbers, as may be directed, and to which every alternate piece is to be fastened at each end by a bolt three-fourths (¾) of an inch diameter and 18 inches long. There are to be two longitudinal timbers dovetailed into and secured to the end pieces at the proper height to form bearings for the floor.

The cribs, from the bottom upwards to low-water line, may be formed either of pine, ceder, ash, tamarack or elm timber; but whatever kind is used it must be straight and of good quality, free from shakes, sapwood, unsound knots or other defects.

Before a crib is put together the contractor must take correct, close soundings over the place it is to occupy when sunk; and where such inequalities occur as cannot be removed, the bottom of the crib must be adapted to them, so that when placed in its berth the sides and ends shall be plumb and the whole form a line corresponding to that marked out by the officer in charge.

Immediately after a crib has been moored in the right position, the contractor, if so directed, must lay a platform of plank over it of sufficient size and strength to carry enough stone to sink it; and when thus sunk and ascertained to be on the proper line and place, the crib is to be filled with an approved class of moderate-sized stone, closely packed.

The square head at the outer end may, up to low water, consist of four cribs, each 30 x 30 feet.

When the whole of the cribs shall have been sunk, well filled with stone and settled in their respective berths, the sides must be brought to an uniform height at low-water

line, either by cutting down and removing the top timbers or using suitable levelling pieces, as may be required.

THE SUPERSTRUCTURE—is then to be commenced and carried up with a batter of one in twelve to the height of other parts of the pier or to such other height as directed. The face timbers to be of pine 12 inches square, generally not less than 40 feet long, or of such other lengths as will break joint properly over and upon the different cribs. They are to be scarfed at the ends where they connect, the scarf to be square at heel and toe and have a lap of 18 inches with a block underneath, and be secured with a bolt 18 inches long and three quarters ($\frac{3}{4}$) of an inch diameter. The timber must be counterhewn, if required, and laid so as to leave a space of $1\frac{1}{2}$ inches between the courses.

TRANSVERSE TIES,—of flatted pine timber of a size to square 10 x 11 inches at both ends and of a sufficient length to extend across the pier, are to be placed not more than 10 feet apart in every course of the superstructure. They are to be dovetailed and let into the side pieces over and under them, have a block of $1\frac{1}{2}$ x 12 x 12 inches inserted between the two courses under the head of each, and be secured by means of rag-bolts seven-eighths ($\frac{7}{8}$) of an inch diameter, in a similar manner to those described for the cribs.

LONGITUDINAL TIMBERS—of flatted pine are to be carried up between the alternate courses, of like dimensions, be framed, notched into cross ties and secured generally as those described for the cribs.

BINDING PIECES—of 4 x 10 inches pine plank are to be placed vertically inside for the entire height and fastened with spikes five-eighths ($\frac{5}{8}$) of an inch diameter and 10 inches long, one at every crossing of a face timber. They are to be not more than 14 feet apart and are in every case to form continuations of the respective ranges underneath.

STRINGERS.—To form bearings for the top covering, five stringers, each 7 x 10 inches of pine, are to be laid the whole length of the extension, secured to the cross ties and placed at a like height as the side timbers.

The whole interior of the superstructure must be filled with a good class of stone, carried up as the timber work proceeds, and care taken to pack them well around and between the ties, as well as to have the top part properly levelled.

TOP COVERING—to be of a good quality of 3-inch pine plank of sufficient length to pass over the side timbers and meet on the centre stringer. They are to be laid crosswise, one inch apart, and be fastened at the ends and at every crossing of a stringer with 6-inch pressed spikes. The covering is to be further secured by chamfered cap-pieces of white oak or rock elm 10 x 6 inches—one range along each side and another in the centre over the joinings of the plank. The cap-pieces are to be fastened with rag-bolts three-fourths ($\frac{3}{4}$) of an inch in diameter and 18 inches long.

If directed, waling pieces 12 x 10 inches, of white oak or rock elm, chamfered on the edges, are to be placed along the channel side of the pier within 5 feet of the top, or at such other height as may be subsequently decided. They are to be fastened with rag-bolts one and one-eighth inch in diameter and 20 inches long, made with good upset heads and driven 8 feet apart, or such other distance as may be required.

The head or outer portion of the pier for a space of about 30 feet square in the centre of the rear part of the west side is to be carried up 6 feet higher than the adjoining super-

structure and be built and secured in like manner as described for the other portions of the work, except that there are to be inside binders on the end from the bottom upwards as well as on the sides, and the inner end of the raised part is to be stepped off or otherwise made to form an easy means of access, and the top covering is to be 5 inches thick.

MOORING POSTS—of white oak or rock elm, 10 feet long and 16 inches diameter, are to be placed in the pier from 40 to 50 feet apart, or at such other distances as may be subsequently determined. They must be properly dressed, covered on top with a cast iron cap-piece, notched at bottom to receive cross pieces 5 feet long, be fastened to the cross ties with screw-bolts of 1¼-inch round iron, and be otherwise secured as directed, placed so as to stand 18 inches over the top covering and have the ballast around them well packed.

The sides of all the superstructure must be hewn down neatly and everything done that is necessary (although not herein particularly mentioned) to place the whole in finished and satisfactory condition.

On the east side of the entrance channel four detached blocks of pier work, each 120 feet long and 30 feet wide, will be built about equal distances apart between the outer end of the east pier and the west end of the reef, on which a large buoy is moored. The cribs of which they are formed must be of timber of like dimensions, framed, put together, secured with rag-bolts and vertical binders connecting the lower course of timber with those above, have their bottoms adapted to the positions they are to occupy, and be in every respect of a similar class of workmanship and material, arranged, sunk and filled with stone ballast as described for those in the extension of the west pier. The superstructure over them to be of pine timber, arranged, framed, fastened with bolts and binders connecting the upper and lower timbers, be filled with ballast and planked on top as previously described for the west pier.

In each of the four blocks three white oak mooring posts are to be placed and secured in like manner as above stated.

The pier work or docking at the south end of the new portion of the basin is to be 20 feet in width, for which a seat one foot below the general bottom must be excavated and prepared; to enable this to be done, a slope of one horizontal to one vertical will be allowed on the south end of the cut. The outer or face timbers of both the crib work and superstructure of this portion of the work must be framed and laid so that the horizontal joints between the different courses of timber shall at no place exceed one half (½) an inch; but in all other respects they are to be framed, put together and secured with bolts and binders connecting the lowest with the upper timbers, and be sunk and filled with ballast as previously described for the extension of the west pier, except that there are to be no longitudinal ties in them. At the outer end where the new and old piers connect, the angle is to be oblique, as indicated on plan.

DOCKING ON WEST SIDE.—The present insecure portion of the old docking on the west side is not to be removed any faster than the contractor is prepared to replace it with the crib work of the new line; but when once commenced, this part of the work must be urged forward as expeditiously as possible.

From the ferry recess outward for a distance of 630 feet the new crib work will be 18 feet in width at bottom, thence for the distance required it will be 30 feet wide at bottom.

To enable the seat for this stretch of the work to be sunk to the required depth of 1 foot below bottom or 6 feet below the lock sill, and the bottom properly levelled for the

cribs, a slope of one to one will be allowed on the rear side, but with the full and distinct understanding that, after the cribs are in place and the pier carried to its intended height, the contractor shall fill and level up the space in rear with the small pieces of the rock excavated from the channel or basin, or in such other way as may be directed, at his own cost and expense, without any claim for compensation other than that allowed for the rear slope above mentioned.

The docking to be of the width stated, formed of crib work in lengths of 30 feet or more, up to low-water line, over which the superstructure will be continuous.

The face timbers of the cribs must be 12 inches square, but the end and rear timbers may be 11 inches square. Ties to be of a size to square 10 x 10 inches, and the floor timbers are to be at least 9 inches thick.

The outer or face timbers of the cribs must be framed and laid so that the horizontal joints between the different courses shall be close for at least two-thirds of their length, and nowhere exceed one-half ($\frac{1}{2}$) of an inch. In all other respects they are to be framed, dovetailed, and secured by means of bolts and binding pieces connecting the lowest with the upper timbers, have blocks under the back ends of the ties, and be of a similar class of work as described for the extension of the west pier, except that the blocks under the ties will be only one inch thick, and that no longitudinal stringers will be used.

The bottoms of the cribs are to be adapted to the respective places they are to occupy when in position, and when sinking them a loaded platform on the top is to be used so that they can be arranged correctly on the line and at the place required. They are then to be filled with an approved class of stone, care being taken wherever practicable to pack the ballast close around and between the ties.

After the tops of the cribs have been brought to an uniform height at low-water line, the superstructure is then to be commenced and carried up with sides and ties of pine timber, framed, dovetailed, fastened with bolts, have blocks under the heads of the ties and be secured with binding pieces, be planked on top and have cap and wale pieces, etc., as described for the upper part of the extension of the west pier, except that there will be no longitudinal stringers other than those required to form bearings for the top covering.

The contractor is not, however, to provide either stringers or plank for the covering of the north half of the docking until officially notified to that effect, as on that part of it a layer of gravel from 6 to 8 inches deep may be substituted for plank.

The superstructure of the east pier, from the new part of the basin outward (520 x 20 feet,) and a large portion, if not all of the west pier (30 feet wide,) must be taken down to water line and rebuilt to about the same height as at present, 19 feet over the mitre sill of the lock.

In both cases the old materials are to be removed down to low-water line, or lower where the timbers are unsound, and must be taken to such places as may be directed, and the stone placed in such positions as will admit of their being used advantageously in the new portions of the works. All iron bolts found in the old works must be carefully preserved, straightened and otherwise prepared for use in the new superstructure. The cost of removal, straightening and subsequently driving them in the new work must all be embraced in the bulk sum tendered for the removal and replacing of old materials per hundred lineal feet of the respective piers.

All the side timbers, ties and stringers of the new superstructure to be of pine timber, of sound and approved quality, framed, put together and secured as herein described.

When a sufficient stretch of the old work shall have been taken up, the sides of the cribs must be brought to an uniform height at low-water mark, either by cutting down and removing the top timbers, or using suitable levelling pieces as may be required.

The side timbers are to be 12 inches square, generally not less than 40 feet long, or of such other lengths as will break over and upon the different cribs. No two joints in adjoining courses are to be nearer each other than 10 feet, and no two vertical joints in the alternate courses are to be nearer each other than 5 feet.

The whole of the work connected with rebuilding the superstructure of the respective piers is to be framed, the timber laid, the ties dovetailed, fastened with bolts and treenails, and be further secured with binding pieces of 4 × 10 inches pine plank, placed vertically inside, not more than 14 feet apart, and extending from at least one foot below water line to the upper side of the top timber, and have every part of the work executed and finished as provided for and described in a preceding part of this specification for the superstructure of the extension to the west pier, except that there will be no longitudinal stringers in the east pier other than those required to form bearings for the plank.

STONE FILLING.—The whole interior of the new superstructure must be filled with stone as the timber work proceeds, and care taken to pack them well around and between ties, as well as to have the top properly levelled. The stones at present in the pier to be used first, all the expenses connected with the removal of which out of the old work and placing them in the new must be embraced in the bulk sum stated in the tender. If other stones are required for filling or levelling, they must be provided by the contractor, and will be paid for at the rate mentioned for those in other parts of the work.

BEACON.

To mark out the south-east side of the entrance channel, a beacon, constructed of timber work, ballasted with stone, is to be placed in about 15 feet of water, near the south-east end of the reef, on which a buoy is at present moored. It is to be octagonal in plan, measuring 50 feet on the diagonals at the bottom, carried up with a batter of one in twelve on all the outer sides to a height of 20 feet over the water surface, where an offset is to be made. In the middle a frame structure is to be erected, of a similar form to the base, and over this there is to be a light iron ball, supported on a pole, placed in the centre for that purpose.

The whole to be framed, put together and secured in the manner herein described and represented on the general plan.

FRAMING.—The face timbers of the beacon, from the bottom up to 20 feet over the water, are to be 12 inches square, of the full length of the sides of the octagon and necessary connections. They are to be framed so as to leave a vertical space of 2 inches between the different courses, and at the angles the respective side pieces are to be connected by double-bevelled dovetails, arranged throughout so that both ends of every timber shall be dovetailed into and between two other timbers on the adjoining sides. At each corner of the octagon, in every course, a rag-bolt 12 inches long and five-eighths ($\frac{5}{8}$) of an inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of a sufficient size to square 10 × 12 inches at both ends—four of which in every alternate course of side timbers must be of sufficient length to reach entirely across the structure—the others to

be of the lengths indicated on the plan, and so arranged that there shall be one tie and, alternately, two ties in a course on each side of the octagon. The ties are in all cases to be at right angles to the outer face or sides in which they are placed, and under the head of each, at the joint between the courses immediately below it, a block 2 × 12 × 12 inches is to be inserted to give an uniform bearing; and a rag-bolt 2½ feet long, and seven-eighths (⅞) of an inch diameter is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and 4 inches into the head of the next cross tie. The inner ends of the short ties are to be notched on and into those that pass entirely through the structure, and be fastened at the crossings with three-quarter (¾)-inch bolts 14 inches long, blocks being placed under the crossings of all the thorough ties, and at such other places as may be required.

The beacon is to be further secured by vertical ranges of plank placed inside and extending from the bottom up to 10 feet over the water surface. There are to be two ranges on each side of the octagon, placed so that they shall be about equal distances apart all round the structure. The planks are to be 4 inches thick and 10 inches in width, fastened with 10-inch spikes five-eighths (⅝) of an inch diameter; two driven into each of the lowest side pieces and one at every crossing of a side timber from the lowest timber upward.

Ballast Floor—to consist of flatted timbers 10 inches in thickness, laid from 5 to 6 inches apart on four transverse bearers and resting on a projection formed by the second course of side timbers, which must be 18 inches in width for that purpose.

The sides and ties are to be of an approved description of rock elm timber, of the dimensions before stated.

If the site is found to be of an irregular height, the inequalities must either be removed or the bottom of the structure adapted to them, and such precautions adopted as will ensure an uniform bearing and a like batter on all sides.

The stone ballasting must be kept up with the wood-work, and care taken that the whole interior shall be fully and properly filled with a good class of stone of such a size as can be easily handled.

At the height of 20 feet over the water surface, the top is to be covered with 3-inch pine plank laid with an inclination outwards, and fastened with 7-inch pressed spikes to proper bearers secured to the sides and ties.

From 4 feet below the water surface to 20 feet over it, the whole of the beacon is to be sheeted with white oak or rock elm plank, five inches thick, and of the full length (23 feet) above stated, well jointed, the lower ends chamfered, and the whole fastened in the manner directed with ragged spikes three-fourths (¾) of an inch in diameter and 12 inches long.

The angles are to be secured with straps of wrought iron, 3 inches wide and three eighths (⅜) of an inch thick, put on over the sheeting and extending 6 feet along each side, fastened with five rag-bolts on a side, one within 8 inches of the angle, one 3 inches from the end, and the other three at equal distances apart. They are to be put on about 14 inches from centre to centre, up to 12 feet over the water surface, thence they are to be 25 inches apart, care being taken in all cases to place them as far above or below the horizontal openings in the sides as will ensure a good hold for the fastening bolts.

The straps are to be punched and the holes countersunk. Bolts to be 12 inches long, three-fourths (¾) of an inch diameter, ragged at the ends, and the necks made to fill the holes in the straps, and have good upset heads.

The upper part of the structure is also to be octagonal, made of framework consisting of eight angle posts of pine, placed so as to have a batter of one in 12 on all sides, and connected by four ranges of horizontal binders, mortised and tenonned into them, and well pinned. Cross pieces are to be notched, framed into and fastened between every tier of binders, and the whole is to be further secured by four wrought iron screw-bolts 1¼ inches diameter at each of the four ranges of binders. The posts are to pass down 7 feet below the top of the offset, be secured to the cross ties with screw-bolts of 1¼-inch iron, and have the stones around the foot of them well packed.

SHEETING—for the outside to be of 2-inch pine plank, dressed, grooved and tongued, and put on vertically, in widths not exceeding 6 inches, and fastened to the binders with 6-inch pressed spikes. Pieces of the same thickness and 6 inches in width are to be fastened at the angles to which the sheeting planks are to abut. The top is also to be covered with 2-inch plank, laid so as to have an inclination outwards.

The centre pole to stand 7 feet over the top of the framework, and pass down 14 feet into the interior, and be well fastened to the different tiers of cross pieces.

BALL—for top to be 3 feet diameter, formed of strips of wrought iron three sixteenths ($\frac{3}{16}$) of an inch thick and 1¼ inch wide, bent to a circular form, placed vertically 1½ inch apart, and riveted to suitable interior pieces. In the bottom part an opening 8 inches diameter is to be formed, and provision made for proper means of fastening it to the pole, both at top and bottom.

PAINTING.—The upper framework portion of the beacon is to be painted three coats; one side of the octagon to be white, and the next red, alternately. The ball to be painted a red color.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan contemplated in this specification and the directions of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or enlarging and deepening the basin, constructing new stretches of pier, rebuilding superstructures of other parts, or the disposal of the excavated or dredged material, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works. inattention or any other cause.

Contractors will see from the printed form of tender that they are expected to state a rate at which they are willing to undertake the removal of the rock measured in the solid, and another rate if the stone after removal be measured in closely-packed piles. It is, however, to be clearly understood that the Department of Public Works reserves the right of accepting either of these offers as a whole, or of accepting the offer for rock excavation in the solid for one or more parts of the work, and that for the measurement of the stone in piles for other parts. To enable the rock to be measured after it has been excavated, the contractor must remove it to some suitable place, and there have

it piled closely in some regular shape, to the full satisfaction of the officer in immediate charge.

The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for the placing or preparing materials beyond the limits of the canal lands in that vicinity. He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipment, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in this specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works as herein described and the instructions that may from time to time be given by the engineer or authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by a deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. *only* of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the first day of June, 1878.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 15th June, 1875.

APPENDIX No. 26.

Welland, November 26th, 1879.

SIR,

As directed by your telegram of the 8th inst., I have the honor to report upon the progress made since December 7th, 1876, in the works of the enlargement on the Southern Division of the Welland Canal.

SECTIONS NOS. 21 AND 22.

These sections, known as the "Deep Cut," and covering a distance of nearly two miles, were let as one contract.

The work has been satisfactorily completed, the canal having a bottom width of one hundred feet at the depth of three feet below the mitre sill of the lock at Port Colborne, with side slopes of 2 to 1 from the bottom to the level of the towing path, and above the towing path the slopes are $2\frac{1}{2}$ to 1.

Since the completion of this contract, some trifling settlements have been noticed at places in the towing path, but not of a nature to cause any uneasiness.

The contract was exclusively earth excavation, 683,397 cubic yards having been removed by dredges, and 657,641 cubic yards by a steam shovel and by scrapers, making a total of 1,341,038 cubic yards of excavation under this contract, in addition to the 416,514 cubic yards of excavation removed from the east bank of the Deep Cut, under R. Mitchell & Co.'s contract.

During the last three years, the side slopes have been much cut up by rain, and the desirability of sodding or seeding them becomes more and more apparent.

SECTION No. 23.

This section, which is 5,280 feet in length, is now nearly completed, little remaining to be done with the exception of the walls and fender works of the old guard lock, which serve as abutments for the present swing bridge, and the adjoining clay bank which supports the fenders.

The appliances for raising the gates of the new guard lock are also not yet completed.

At the close of navigation in December, 1877, the contractor commenced forming a dam across the canal at the north end of the section, to keep the water in the Deep

Cut, at or above Lake Erie level, when the remaining portion of the summit level between Port Robinson and Port Colborne was unwatered.

Another smaller dam was also formed to the south of the site of the new guard lock, to keep back-water from the Chippawa Creek from flooding the guard lock pit.

There was difficulty in making the dam at the north end of the section secure; so much so, that it was not until the 23rd of January, 1878, that the excavation below the dredged bottom was commenced.

The extreme mildness of the winter of 1877-78, and the quantity of rain which fell, increased the difficulties of a quicksand bottom and delayed the excavation beyond all reasonable expectation.

The centre pier, side piers and the main portions of both abutments are built on a continuous timber platform, 188 feet long and 29 feet wide, which platform rests on a bed of concrete of an average depth of 18 inches, the concrete being confined by sheet piling.

The first timber of the platform was placed February 20th, 1878, and building was commenced March 15th, 1878.

Building progressed rapidly, and the abutments, seat piers and centre pier were raised above the level of Lake Erie before the opening of navigation in May, 1878, and were afterwards completed when a season of low water permitted.

The crib portion of the dam at the north end of the section was displaced to such an extent as to encroach upon the site of the north rest pier, and it became desirable to substitute piles for this pier and the proposed crib work north of it.

Crib work was also substituted for the south rest pier.

A portion of the stone for these rest piers was dressed before the necessity of substituting timber made itself apparent, and the stone thus dressed is now upon the ground.

A road has been graded in rear of the spoil bank on the west side of the canal to accommodate the travel which now crosses the canal at the present swing bridge, and which will pass over this road to the new swing bridge at the guard lock when the superstructure is built.

On the east side of the canal a road has also been graded from the new guard lock to connect with Island Street, in the Village of Port Robinson.

At the commencement of this season's work it was expected that the dredging would be completed on this section, and to admit of this being done, a ferry scow was provided and brought to Port Robinson, to be in readiness for use when the time arrived for removing the present swing bridge and abutments, etc.

It was considered proper, however, not to interrupt the travel at the swing bridge until other portions of the dredging were completed, and although two dredges have been working during the summer, there still remains work for the dredges without commencing the removal of the present swing bridge.

It appears therefore as if the ferry scow would not be brought into use until next season, and should the new bridge superstructure be put up this winter, the ferry scow will not be required there.

The following quantities of work have been returned to date :—

Earth excavation,	cubic yards	218,621
Timber in guard lock bottom,	cubic feet	5,795
" " gates,	"	2,430
Pine plank,	M. ft. B.M	37,880
Masonry,	cubic yards	2,573
Concrete,	"	542
Loose stone in banks,	"	1,263
White oak piles,	lineal feet	6,815
Iron in bolts, etc.,	lbs	32,526
White oak timber,	cubic feet	2,741
" plank, etc.,	M. ft. B.M	23,549
Grading roads,	rods	78
Timber in cribs,	lineal feet	18,262
Stone filling in cribs,	cubic yards	1,166
Brass in lock gates,	lbs	670

SECTION 24.

This section is now completed, the work being entirely excavation; the length of the section is 5,190 feet, and the quantity of excavation returned to date is 258,711 cubic yards.

SECTION 25.

This section is a mile in length, and in addition to excavation, comprised the erection of the piers, abutments and crib-fender works for the new swing bridge to be built on the line of the Quaker Road.

When the summit level of the canal was unwatered after the close of navigation in December, 1877, clay dams were put in above and below the site for the bridge works, and the excavation was proceeded with as rapidly as circumstances would permit.

The bridge piers and abutments were built on a foundation of timber and plank, the timbers being placed six inches apart, and the spaces between them filled with concrete.

The bottom is clay throughout.

From the delay occasioned by frequent wet weather, it became evident that the entire excavation could not be taken out in time to admit of the bridge works being completed by the opening of navigation; it was therefore determined not to excavate for the east seat pier and abutment, as the shape of the ground admitted of their being built the following summer.

The centre pier, rest piers and west seat pier and abutment, together with the crib fenders for the centre and rest piers, and pile fenders for the west seat pier, were put in between December 6th, 1877, and May 1st, 1878; and after the opening of navigation, the excavation for the east seat pier and abutments was taken out, and the masonry and fenders completed during the summer of 1878.

The dredging has since been finished, or nearly so, and with the exception of two or three trifling matters the contract is now completed.

The length of the section is one mile, and the principal items of work returned to date are as follows :—

Earth excavation,	cubic yards.....	378,982
Pine timber in foundations,	" feet.....	1,050
Plank, caps and wales,	M. ft. B.M.....	28,662
Crib timber, etc.,	lineal feet.....	22,994
Masonry,	cubic yards.....	2,816
Concrete,	"	31
White oak piles,	lineal feet.....	5,378
Iron bolts, etc.,	lbs.....	12,963
Stone filling in cribs,	cubic yards.....	1,379

SECTION 26.

With the exception of two small culverts for carrying streams under the towing path, the work on this section is excavation, and a large portion of it is exceeding hard.

The contract is now so near completion that it will probably be completed before the close of navigation this season.

The quantities returned to date are as follows :—

Earth excavation,	cubic yards.....	313,897
Culvert masonry,	"	141

The length of the section is one mile.

SECTION 27.

The contract for this section was signed September 26th, 1877, and work was commenced on the 12th of the following month.

The section is 5,580 feet in length, and in addition to the excavation for widening and deepening the canal, comprises the following structures :—

A stone aqueduct to carry the traffic of the Welland Canal across the Chippawa River.

Its length is 460 feet, width between the retaining walls 85 feet, and is to to be supported on six arches of 40 feet span and 7 feet rise, the crown of the arches being 8½ feet below low water in the Chippawa River.

These arches will therefore be syphons through which the Chippawa River will flow as it does at present under the existing aqueduct.

The new aqueduct is located on the up-stream side of the present one, parallel to it with a space of seventy-five feet between them.

The piers, abutments and fender works for a swing bridge on the line of Division Street, in the Town of Welland ; the change in the site of the bridge from Main Street being rendered necessary by the requirements of a channel to accommodate the large class of vessels that are expected to pass through the enlarged Welland Canal.

The removal of the present lift lock, which occupies a portion of the site required for the new aqueduct, and the construction of another lift lock for communication between the canal and Chippawa River.

The construction of a covered drain 661 feet in length on the east side of the canal, as a substitute for a syphon culvert under the canal, which has to be removed to give the required depth of water; and the construction of retaining walls, crib work and other minor works.

The contract provided that the covered drain should be completed in the autumn of 1877, that the works in connection with the aqueduct should be commenced the same autumn, and the piers, abutments and fender works for the new swing bridge built when the canal was unwatered between the close of navigation in 1877, and the opening of navigation in the following spring.

The covered drain was commenced in the autumn of 1877, the piers, abutments and fender works for the new swing bridge, with the exception of the west seat pier and abutment, were built in the winter of 1877-78, but the aqueduct works were not commenced in the autumn of 1877, the lateness of the season when the contract was entered into making it difficult to obtain all the necessary dredging plant.

The dredging for widening and deepening the Chippawa River at and near the site of the new aqueduct, was commenced in June, 1878, and driving piles for the coffer dam for the first section of the aqueduct and south oblique wall, to connect the present and proposed aqueducts, was commenced July 15th, 1878.

On the 2nd of October, 1878, the double row of piles for this portion of the coffer dam being driven and the spaces between them filled with clay, obtained from the lock-pit, the pumps were started. The coffer dam leaked badly and eventually gave away on the west side, the rods which tied the rows of piles together parting on the night of October 10th, 1878, and making a wreck of about 130 feet in length of the dam.

The contractors at once commenced to repair the breach by forming a new piece of dam of a different construction outside the part that had failed, and when this was completed and other parts of the dam strengthened by additional tie rods, walings and stay piles, the pumps were again started on the 27th January, 1879.

After contending with leaks of a greater or less size, which frequently gained on the pumps, the portion of the coffer dam here referred to was eventually laid dry February 10th, 1879, and the excavation for the foundations was commenced with men and teams.

On the east side of the aqueduct pit, toward the south end, where the south oblique wall (item 23 in the form of tender) is built, the site of the wall comes so near the present canal that no slope could be given to the excavation, and it was necessary to support that side of the pit. This was being done by driving a close row of piles parallel to the back of the wall, which piles were to be shored from pile buttresses to be driven inside the coffer dam, and far enough from the row of close piles to admit of the oblique wall being built in the intervening spaces.

Only a few of the piles forming the close row had been driven when the toe of the rear slope of the canal bank, which extended into the aqueduct pit, began to move, and caused cracks in the canal bank, which opened to within a few feet of the water line in the canal, and, considering the locality, threatened a break that would have been disastrous.

Under these circumstances, I directed the contractors to flood the aqueduct pit from the river, and this was done April 10th, 1879, the movement of the bank ceasing when the pit was flooded.

Flooding the aqueduct pit, caused another delay, and obliged the construction of a separate coffer dam for building the south oblique wall, as provided for in clause 10, page 7, of the specification.

Two pile drivers were employed at this work, and the pile driving being completed, the excavation was proceeded with.

On the 19th of July, 1879, when you visited the works, the excavation for a length of sixty feet had nearly reached the required depth (44 feet 3 inches below the towing path), and the bottom being found as indicated by the borings previously taken, concreting was commenced shortly afterwards.

The concrete, to a depth of 2 feet 6 inches, was put in in layers of about 10 inches, and well rammed, and having been allowed time to set, building was commenced on the 4th of August, 1879.

While the first length of masonry was being built another length of excavation was being proceeded with, and in this manner the south oblique wall and a portion of the retaining wall and south east wing wall of the new aqueduct was raised high enough to secure the canal bank and admit of the aqueduct pit being again pumped out.

The pumps were again started October 20th, 1879, and on the 4th of November, 1879, the pit was unwatered.

Since the pit has been unwatered the portion of the canal bank which is to be removed to the west of the south oblique wall has again commenced moving, leading to the inference that had the water not been let into the pit when it was, a breach in the canal bank would have occurred.

In accordance with your instructions, the contractors are working with a view to putting in the concrete foundations for the aqueduct this winter, and should the weather permit, and no further difficulty be experienced with the coffer dam, building on the piers, inverts and south abutment should proceed early next summer.

The preparation of stone for the aqueduct has been progressing at quarries near Queenston, Thorold and Beamsville, where gray limestone of excellent quality is obtained and a considerable quantity of stone for the inverts, piers and arches is already on the ground.

The stone from Queenston and Beamsville is being delivered by rail, and from Thorold by boat.

The covered drain was completed in September, 1878, and in addition to the new portion of the drain the original part, 422 feet in length, which was going to pieces, was taken out and rebuilt.

Earth excavation in drain, cubic yards.....	17,000
Masonry in drain "	1,530

The bottom of the lock pit being soft, a concrete foundation was considered desirable and a layer of concrete was put in 12 inches deep under the walls and 6 inches deep between the walls. On this concrete, pine timbers 12″ x 12″ were laid six inches apart and the intervening spaces were filled with concrete.

Above and below the mitre sill platform, sheet piling 6 feet in length was put in across the entire pit, and at the lower end of the lock another range of sheet piling was also put in, the sheet pile trenches in every case being filled with concrete.

A course of 3-inch planking covers the entire surface of the lock bottom, on which the walls are built. The space between the walls will have an additional course of 2-inch planking.

The lock masonry was commenced September 13th, 1879, and when building was discontinued on the 18th of November, both walls were eight courses high, or 16 feet 10 inches above the floor. The breast wall is also completed. Lock masonry returned to date, 2,610 cubic yards. The remainder of the stone for the lock is prepared, with the exception of a small quantity of dimension stone, and the greater part of the stone is on the ground.

The bank behind the walls has been made up in layers to the same height as the masonry, 3 feet in width next the walls, being well cut and rammed and puddled thoroughly.

The size of the lock is 150 feet from mitre to mitre; width of chamber 26 feet 6 inches at the bottom, with a batter of 1 in 24 in the chamber, and the height of the walls will be 31 feet.

The lift of the lock from low water in the Chippawa River to Grand River level on the canal will be 19 feet.

From the south-east wing of the lock a line of crib work has been put in 177½ feet in length, to protect the north-west bank of the Chippawa River, between the lock and aqueduct, from scour at high stages of the river.

The west seat pier and west abutment of the new swing bridge were put in this summer, there being room to excavate for them without any material difficulty.

The remainder of the excavation between the centre pier and west seat pier will be removed by dredging.

The piers, abutments and fender works of the new swing bridge are now completed with the exception of the pile fenders on the west side, and the caps, wales and anchor timbers of the pile fenders on the east side.

Masonry in the bridge piers, abutments and slope walls, returned to date, 2,414 cubic yards.

In the excavation for the prism of the canal on the north side of the aqueduct, 21,644 cubic yards has been removed, and on the south side of the aqueduct 66,422 cubic yards has been removed; these quantities represent about ·38 per cent. of the excavation for enlarging the prism. The total quantity of earth excavation returned on this section to date is 175,230 cubic yards; masonry, 8,862 cubic yards; concrete, 791 cubic yards; iron, 24,544 lbs.; piling, 6,664 lineal feet; crib timber, 66,934 lineal feet; pine plank, 61,591 feet B.M.; stone filling, 4,079 cubic yards.

Section 28.

This section is 4,970 feet in length, and in addition to excavation for enlarging the prism, the contract comprises the piers, abutments and fender works for a new swing bridge.

It is on this section that the Canada Southern Railway crosses the Welland Canal, but the works in connection with the Railway Bridge were executed by the Railway Company.

The piers, abutments and fender works for the canal swing bridge were built during the winter of 1877-78, and the excavation will probably be completed next season.

The principal quantities of work returned to date are :

Masonry,	cubic yards.....	3,120
Timber in cribs,	lineal feet.....	23,780
Piles in fenders,	"	3,370
Iron in bolts,	lbs.....	9,833
Stone filling in cribs,	cubic yards.....	1,400
Pine timber in bridge foundations,	cubic feet.....	996
Pine plank 3",	feet B. M.....	6,622
Earth excavation	cubic yards.....	194,152

SECTION 29.

One mile in length, completed in 1876.

SECTION 30

Is one mile in length, and is exclusively excavation, 401,456 cubic yards having been returned to date.

This section was nearly completed in October, 1877, with the exception of about 700 feet in length where the temporary bridge stood which carried the Air Line of the Great Western Railway over the canal.

The excavation could not be completed until a new bridge was built by the Railway Company, which new bridge was not in a condition to admit of dredging being resumed until after the opening of navigation in 1878.

When the detention occurred in October, 1877, the dredging plant was removed to other sections, and it was not until July, 1879, that the work of removing the remainder of the excavation at the Air Line Bridge was resumed, and that part of the work is now nearly completed.

During the interval which occurred from October, 1877, to July, 1879, and especially during the winter of 1877-78, the towing path on both sides of the canal was washed out and settled away in many places, and this material is now in the bottom of the canal, chiefly at the foot of the slopes.

SECTIONS 31 AND 32.

These sections were let as one contract, the work contracted for being the formation of back ditches and the widening and deepening of the prism of the canal for the entire length of these sections, which is 9,280 feet, with the exception of the ground in the immediate neighborhood of Lyons' Creek Culvert, which was not to be interfered with.

The new culvert to carry Lyons' Creek under the canal was not included in the contract.

Section No 31 is one mile in length, and the length of Section 32 is 4,000 feet.

The work contracted for has been completed, the quantity of excavation being 653,101 cubic yards.

SECTION 33.

This section is one mile in length, and in addition to earth excavation embraces rock cutting and the building of slope walls, the removal of a slide on Section 32 containing about 23,400 cubic yards, and the construction of a culvert to carry the waters of Lyons' Creek under the canal on Section 31.

The contract was awarded to the late Ambrose Clark, of Buffalo, and work was commenced in December, 1877, by putting in a flat dam at the north end of the section, the summit level of the canal being unwatered to the level of the Chippawa River.

Comparatively little work was done on the section until the summer of 1878, when the dredging progressed fairly.

The removal of the spoil bank was proceeded with, and materials for Lyons' Creek Culvert were brought upon the ground and prepared.

At the close of navigation early in December, 1878, the water in the summit level of the canal was lowered to Lake Erie level, and a crib dam was put in at the north end of Section 33, to admit of the portion of the canal south of the dam being unwatered.

At Lyons' Creek Culvert, two crib dams were also put in, to admit of the site of the new culvert being unwatered.

The death of the contractor, which occurred on the 10th August, 1878, was a serious loss to the work, which was continued by his legal representatives and others associated with them by private arrangement.

The new culvert for Lyons' Creek was brought near completion in time for the opening of navigation ; it has since been completed and is now in use.

In the rock cut, at and near Ramey's Bend, the result of the winter's work was as unsatisfactory to the contractors' representatives as it was to the Department of Public Works.

The earth excavation was not in a sufficiently forward state when the section was unwatered to admit of the machinery for removing the rock being worked to advantage, and the progress made was far below what had been expected ; 263,081 cubic yards of clay excavation, 29,871 cubic yards of rock excavation, and 1,623 cubic yards of masonry in side walls, has been returned to date, exclusive of the quantities at Lyons' Creek, and no portion of the rock cutting has been lowered to the required depth.

Between the north end of the section and Ramey's Bend, a ridge of rock, which rose about a foot above the present bottom of the canal, was sufficiently removed to improve the navigation materially, but was not taken down to the bottom.

The amount of work remaining to be done is estimated to occupy the time until the opening of navigation in 1881, the date named for completing the work in the tenders for re-letting now under consideration.

The removal of the old Lyons' Creek Culvert is now being proceeded with, and will probably be completed this season unless severe weather prevents it.

The following quantities have been returned for work done at Lyons' Creek Culvert to date :—

Earth excavation,	cubic yards.....	40,727
Pine timber in bottom,	" feet.....	4,000
Pine plank in sheet piles and bottom,	M. ft. B.M.....	16,472
Puddle,	cubic yards.....	872
Concrete,	"	340
Wrought iron tie rods,	lbs.....	1,900
Copper "	"	3,400
Masonry,	cubic yards.....	1,755

The culvert, (a syphon) as will be seen by the items just given, is of masonry, on a timber foundation ; the walls are 3′ 6″ high, opening 8 feet wide, and rise of arch 2′ 6″.

The length of the trunk is 231 feet, outside of which are wells at each end, 8 feet square at bottom, and 41′ 6″ high from floor to coping.

The arch stones are 21 inches thick, and are secured with dowels in their beds and end joints.

As an additional safeguard against outward pressure, in the event of the canal being unwatered, the culvert is further strengthened by means of longitudinal timbers under the walls and above the backing of the arch, with cross timbers over the arch at intervals of six feet.

At every intersection of the longitudinal and cross timbers, iron and copper tie rods alternately pass through the cross timbers and top and bottom longitudinals, and are firmly screwed up.

A covering of concrete 3′ 6″ thick, under the bottom of the canal, and 1′ 6″ thick under the canal banks has been placed over the arch from end to end.

Above the concrete there is 2 feet of puddle throughout.

Section 34.

This section is 5,113 feet in length, and was also awarded to the late Ambrose Clark.

The work to be done embraced earth and rock excavation, masonry in side walls and the piers, abutments and fender works for a swing bridge on the line of Main Street, in the Village of Stonebridge.

The rock is met with in the bottom for nearly the entire length of the section.

Work was commenced on this section early in November, 1877, the stripping of the rock and the removal of the spoil bank on the west side of the canal being proceeded with south of Stonebridge.

Sections 33, 34 and 35 were worked as one, as far as unwatering was concerned, the only dams being the one at the north end of Section 33 already referred to, and the dam at the lock gates at Port Colborne.

A powerful steam pump was put in at the north end of Section 33, another near the north end of Section 34, and another about the centre of Section 34. These pumps were worked by the contractor for Sections 33 and 34.

An arrangement was made between the contractors for Sections 34 and 35, by which the contractor for Section 35 bore the expense of sinking a pump pit at the north end of Section 35, where the contractor for Section 34 supplied and erected a powerful steam pump and worked it, and the working expenses were divided by the contractors for Sections 34 and 35.

In the month of January, 1878, rock excavation was commenced on Section 34, south of Stonebridge, and until the opening of navigation, the force was employed chiefly from Stonebridge southwards on the west side of the canal.

Spoil ground was purchased by the contractor on the west side of the canal, south of Stonebridge, as provided for in the contract, and on this ground the bulk of the material excavated was spoiled.

For about one hundred feet the rock excavation was taken down to the required depth in the present channel and widening on the west side, and the remainder of the material excavated was taken from the strip to be removed on the west side of the canal.

A small quantity of slope wall was also built, there being difficulty in obtaining sound stone in consequence of the high explosive used in removing the rock.

The water was let into the canal early in May, 1878, necessitating the stopping of the rock excavation, and shortly after the opening of navigation the dredging was pushed vigorously, good progress being made.

During the summer of 1878 materials for the bridge piers, etc., etc., were brought upon the ground and prepared, and it was expected that the following winter would see a large amount of work accomplished.

At the close of navigation in December 1878, the section was again unwatered without other dams than those on Sections 33 and 35, and a strong force was employed in excavating for the bridge piers, etc.

A temporary bridge was built across the canal, a short distance south of Stonebridge, to accommodate the travel, and the swing bridge on the line of Main Street was then removed.

Beyond the work of the force employed at the bridge pit, and in the immediate neighborhood of the bridge pit, very little was done on the section except excavating a trench for drainage between the bridge pit and the pump south of Stonebridge.

The bridge pit excavation was not completed in time to admit of the bridge piers, abutments and the fender works necessary to protect them being built, and the result of the winter's work was most disappointing.

The water was let into the canal May 3rd, 1879, and a ferry scow was employed as a substitute for the swing bridge on the line of Main Street.

Dredging was resumed shortly after the opening of navigation, and a small quantity of earth excavation was removed by teams at the south end of the section, but no attempt was made to push the work ; and shortly after the channel was dredged clear of the dams and other obstructions that had interfered with navigation in the early part of the season, the works came to a complete standstill, in which condition they have been ever since, and are now about to be re-let.

Following are the principal quantities of work returned to date :—

Earth excavation,	cubic yards.....	162,132
Rock "	"	62,369
Masonry in side walls, cubic yards.....		460

SECTION 35.

This section is 2,292 feet in length and comprises the building of a new lock, an open, also a covered raceway, a supply weir, the piers, abutments and fenders for a new bridge to carry the Grand Trunk Railway over the canal, also the deepening of the basin immediately outside the lock.

Work was commenced in the lock pit October 13th, 1877, and fair progress made before the frost set in.

At the close of navigation a dam was formed at the head gate of the lock by means of tarpauling, manure and clay, which effectually stopped the water.

The rock excavation in the lock pit and prism of the canal was then proceeded with and good progress made.

For the length of the present lock chamber a concrete wall was formed behind the east wall of the lock from the bottom of the lock pit up to the surface of the lock, to guard against leakage from the lock when the chamber was filled with water.

The extreme north end of the east wall of the lock was taken down to admit of the direction being changed, and the wall rebuilt and extended northward a distance of 134 feet to the point which forms the south rest pier of the new swing bridge for the Grand Trunk Railway.

From the north end of this wall, a short piece of crib dam was put in to connect the wall with the canal bank, and admit of the new lock pit being unwatered in the summer.

At the north end of the section the side walls of the canal were also commenced, good stone for the purpose being found in the rock excavation.

On the 1st of May, 1878, the water was let into the canal, and on the 7th of the same month the canal was opened for navigation as far as Allanburgh, the propellers *Oswegatchie* and *Cleveland*, downward bound, reaching Allanburgh lock that day.

During the summer of 1878 the work was chiefly confined to the excavation of the lock, raceway and weir pits, and the delivery and preparation of stone for the structures.

A considerable quantity of stone was delivered by the Canada Southern Railway from the Maldon quarries near Amherstburg, the remainder coming from the Queenston and Beamsville quarries.

These remarks refer to the face stone, the backing being taken from the rock cuttings, with the exception of a small quantity which was brought from Nebellhoor's quarry at Point Abino.

At the close of navigation in December 1878, a dam was again formed at the head gate of the lock, as already described, and when the section was unwatered, operations were resumed in the prism and in the pit for raceway and supply weir.

During the winter, fair progress was made in the excavations and in building the side walls of the canal.

The north-west wing wall of the lock was taken down and rebuilt to answer as the east abutment of the supply weir, and the west abutment was raised high enough to admit of a plank dam being constructed from one abutment to the other, thereby putting the raceway pit in shape for the summer's work.

The water was let into the canal May 3rd, 1879, and the contractors then turned their attention to getting in the lock bottom and continuing the excavation of the raceway. Cutting the checks in the rock bottom for the stop-water timbers of the lock and putting them in occupied much time, and it was not until August 8th, 1879, that the bottom was ready to commence building.

Since that date, building has progressed steadily, and the lock walls are now eight courses high (16½ feet) from the north end of the lock to the south recess, beyond which point the pit is not yet excavated, in order to avoid difficulty with water as long as possible.

In the raceway the east wall of the open raceway has been completed from the north end for a distance of 360 feet, and the masonry of the covered raceway has been completed from the north end for a distance of 330 feet.

The stone for completing the lock and raceway is in a forward state of preparation, a considerable quantity being on the ground.

The contractors are now preparing stone for the piers and abutments of the G. T. Railway bridge, and have facilities for transporting it from Queenston quarry to the work by rail.

The timber for the crib fenders is also expected to be delivered by rail in good time, and unless some unforeseen difficulty arises, the work on the section will be completed by the opening of navigation next spring, with the exception of the south ends of the lock and raceway.

The following are the quantities of the principal items of work returned to date :—

Earth excavation,	cubic yards	99,983
Rock "	"	56,551
Concrete,	"	1,928
Masonry	"	17,839
Timber in foundations,	cubic feet	10,336
Pine plank "	ft. B. M.	32,053
Timber in mitre sills,	cubic feet	1,246
Iron in foundations,	lbs.	12,200

Section 36.

This section would probably have been completed by this time had it not been for a long continuance of boisterous weather, when it was impossible to work outside the harbor.

The work remaining to be done is cleaning up portions of the bottom, which should be accomplished in a month of fair weather.

Under this contract, the east pier, 510 feet in length, has been rebuilt from the sound crib work up the level of 7 feet above lake level.

The docking on the west side of the basin, which was in an unsatisfactory condition, has been dredged out, and a new docking formed of cribs 18 feet wide, with a superstructure of the same width, and carried to the height of seven feet above lake level, has been built for a length of 660 feet.

The superstructure of the original west pier has been renewed, and the pier has been extended 420 feet into the lake, making the length of the west pier as it now stands, 2,108 feet; the new portion being 30 feet wide at the narrowest part, with an enlargement at the end 60 feet square, on which a lighthouse has been erected by the Marine and Fisheries Department.

On the general line of the east pier, but deflecting somewhat from it to the west, four detached blocks of crib work have been built, each block being 120 feet long and 30 feet wide, and raised to the same height as the piers.

In continuation of the line of these blocks, an octagonal beacon, measuring 50 feet on the diagonals at the bottom, and carried to a height of 19 feet 9 inches above lake level, surmounted by a frame structure with a ball on the top of it 47 feet above lake level, has been built in a position to mark the point of the reef, which runs out into the lake from the east side of the harbor.

Across the south end of the basin, as now enlarged, a line of docking, 138 feet in length, connects the north end of the east pier with the side walls on the east side of the basin, the area of the basin as now enlarged being 12·20 acres.

At the north end of the basin the depth of water has been increased to 16 feet when the water on the lock mitre sill is 12 feet deep, and the depth gradually increases to the south end of the basin, where it is 17 feet deep.

From this point southwards to the end of the west pier the depth is 17 feet, and the channel gradually widens from 150 feet at the north end of the east pier to 420 feet at the south end of the 2nd detached block, from which point the channel is 420 feet wide to the point where 17 feet of water is found in the lake.

The quantities returned to date are as follows:—

Earth excavation	cubic yards.....	159,279
Rock "	"	27,875
Old east pier and west docking removed	"	27,218
Timber 12 x 12	cubic feet	83,277
" 10 x 12	lineal feet	13,319
" 11 x 11	"	83,673
" 10 x 11	"	158,498
" 10 x 10	"	29,695
" 7 x 10	"	17,693
" 6 x 10	"	12,168
" 4 x 10	"	14,683
Pine plank, 3"	M. ft., B.M.....	299,100
Rock elm, 5"	"	17,280
Wrought iron	lbs.....	113,354
Stone filling	cords.....	6,785

The preceding remarks are a summary of the information furnished you in detail from time to time during the progress of the works, and will, I trust, serve to bring to your recollection circumstances with which you are already familiar.

I have the honor to be, Sir,

Your obedient servant,

W. G. THOMPSON.

JOHN PAGE, Esq.,

Chief Engineer of Canals,

Ottawa.

APPENDIX No. 27.

BURLINGTON BAY CANAL.

SPECIFICATION of Repairs to be made to the SIDE PIER WORK of the Channel.

The works for which the tenders are invited consist in the removal of the upper works of that part of the north pier recently injured by fire, and forming at that place a new superstructure, together with such repairs to other parts of the piers as may be directed by the Department of Public Works, all of which are to be executed in the manner herein described.

The part of the pier to be taken down and reconstructed extends lakewards from the westerly end of the north pier, or from such other point as may be subsequently determined, for a distance of 1,100 feet or more, if directed. It is generally 20 feet in width, except for about 100 feet at the westerly end, where it varies from 30 to 34 feet in width.

The old materials are to be removed to low-water line, or lower where the side timbers or ties are unsound, and must be taken to such places as may be directed, and the ballast stones placed in such positions as will admit of their being used advantageously in the new portions of the works. It is to be distinctly understood that great care must be taken to guard against any of the stone getting into the canal, and that in case any of them accidentally or otherwise get into it, they must be immediately removed by the contractor at his own cost and expense.

All iron bolts found in the old works must be carefully preserved, straightened and otherwise prepared for use in the new superstructure.

The cost of removing, straightening and preparing the old bolts and of subsequently driving them into the new work, together with the removal of all materials from the old superstructure, rearranging and placing the old ballast stone in the new work, must all be embraced in the rate "tendered," per lineal foot of pier, for the removal and replacing of old materials.

The side timbers and stringers of the new work must be of pine timber of sound and approved quality, free from shakes, unsound knots, rots or other defects; framed, put together and fastened as herein described and as circumstances may require to secure a strong and substantial class of work.

When a sufficient stretch of the old work shall have been taken up, the top sides of the crib work must be brought to an uniform height at low-water line, either by cutting down or removing some of the upper timbers, or using suitable levelling pieces, as may be required.

The side timbers are to be 12 inches square and 12 inches thick by 13½ inches deep, generally not less than 40 feet long, or of such other lengths as will break joints over and upon the different cribs. No two joints in different courses are to be nearer each other than 10 feet, and no vertical joints in the alternate courses are to be nearer each other than 5 feet.

The timbers are to be counterhewn if required, laid so as to leave a space of one inch and a half (1½) between the courses, except the rear part of the pier, from the water line outwards to a depth of 8 feet of water, where they are to be laid as close as possible to prevent sand or shingle from the beach working through the pier into the channel. The sides to be carried up to a batter of one in twelve, and to a like height as the general line of the present pier.

The side timbers to form close butt-joints at the ends where they connect, except in the top round or upper course of timber, where the joints are to be scarfed at the ends: the scarf to be square at heel and toe and have a lap of 18 inches.

Underneath the butt-joints and also those that are scarfed, there must be a block 1½ x 12 x 18 inches. Each scarf joint to be secured by means of a bolt 18 inches long and three-quarters (¾) of an inch diameter, and each end of a timber at the butt-joint to be secured with a bolt of like dimensions.

TRANSVERSE TIES,—of flatted pine timber, of a size to square 10 by 11 inches at both ends, and of sufficient length to extend across the pier, are to be placed not more than 10 feet apart in every course of the superstructure, and so arranged that the ties resting on the different rounds of timbers shall be mid-way between those of the courses immediately below and above.

Their ends are to be dovetailed 3½ inches into the timbers under and over them, the dovetail to splay 1½ inch on both sides, so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie at the point between the courses immediately below it, a block 1½ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt 2 feet long, seven-eighths (⅞) of an inch diameter, is to be driven through the head of each tie.

LONGITUDINAL TIMBERS—At the end where the pier is 30 feet or more in width, longitudinal timbers of flatted pine 10 inches thick are to be carried up between the alternate ranges of ties. They are to be framed and notched into the cross ties, have blocks under them, and be fastened at the crossings by means of white oak treenails 2 inches diameter and 16 inches long. Where the new and old works connect, the side timbers are to be scarfed on to each other and secured in such a manner as may be directed.

BINDING PIECES—of 4 x 10 inches pine plank are to be placed vertically inside of both the front and rear sides of the pier for its entire height, and fastened with spikes five-eighths ($\frac{5}{8}$) of an inch diameter and 10 inches long; one spike at every crossing of a side timber. They are to be not more than 13 feet apart and placed immediately after the second course of timber is put on. They must, in every case, extend from one foot below water line to within 4 inches of the top of the pier, and be spiked to the old timbers at 6 inches or more under the water surface.

STRINGERS.—For 100 feet or more at the end of the pier, the top, if found necessary, is to be covered with plank to form bearings, for which stringers 7 by 10 inches of pine are to be secured with 8-inch pressed spike, driven through the lower angle into the cross ties. Their tops are to be on the same level as the side timbers.

There are to be five ranges of stringers in the 30 feet wide part of the pier, and three, when directed, where the width is 20 feet.

BALLAST OR FILLING.—The whole interior of the superstructure must be filled with ballast in the following manner *i.e.*, the stones in the present pier are to be placed along both the inner sides of the work and carried up to within 9 inches of the finished height of the top, and for such a width on both sides as can be done with the stone available from the old work, within a stretch of pier to be rebuilt. In case there is not a sufficient quantity to fill the entire space, the middle part can be made up of an approved class of coarse gravel or shingle, such as can be obtained within $2\frac{1}{2}$ miles of the place; the top part of the pier is then to be covered to the full height of the side timber with a smaller and finer class of gravel, such as may be approved by an officer entrusted by the Department with that duty.

The coarse gravel for filling, as well as the fine gravel required to form the top covering, will be paid for at the rate stated in the tender.

PLANK COVERING,—where required and ordered, is to be of pine, 3 inches or 5 inches in thickness, as may be directed, laid at right angles to the channel or otherwise, one inch apart, and fastened at the ends and at every crossing of a stringer with pressed spikes four inches longer than the thickness of the plank they are to secure.

Where the pier is 30 feet or more in width, the plank must be of sufficient length to pass over a side timber and meet on the centre stringer; and where required on the 20 feet part of the pier, every three planks in width must break joints properly with those on each side of them. The covering is to be further secured by chamfered cap-pieces of white oak or rock elm timber, each 10 by 6 inches; one range laid along each side, and where the pier is 30 feet or more in width, there will be a range along the centre over the joining of the plank. The cap-pieces are to be fastened with rag-bolts three-quarters ($\frac{3}{4}$) of an inch diameter and 18 inches long.

If directed, waling pieces, 12 x 10 inches, of white oak or rock elm, chamfered on the edges, are to be placed along the channel side of the pier, within five feet of the top, or at such other height as may be subsequently decided. They are to be fastened with rag-bolts, one inch and one-eighth ($1\frac{1}{8}$) in diameter, 20 inches long, made with good upset heads, and driven eight feet apart, or such other distance as may be required.

Where the waling pieces on the old pier require to be renewed, either for short or long stretches, on either or both sides of the channel, the contractor must do the work, if so directed, at the rate stated in the tender.

Any repairs that may be required, and which the contractor may be directed to do to the plank covering of the old piers, on either the north or the south side of the channel, must be done at the prices tendered.

Stone for ballast, required to be furnished for any part of the pier-work on either side of the channel, must be provided, delivered and placed in the work by the contractor at the price stated in the tender.

The prices tendered for timber-work, iron, etc., it is to be distinctly understood, are to be applied as payment in full for all such repairs as the contractor may be called upon or requested to make to the existing pier-work on either side of the channel.

MOORING POSTS—of white oak or rock elm, 9 feet long and 16 inches diameter, are to be placed in the pier from 50 to 60 feet apart, or at such other distances as may be subsequently determined. They must be properly dressed, covered on top with an approved cast iron cap-piece, notched at bottom to receive cross pieces five feet long, be fastened to the cross ties with screw-bolts one inch and a quarter ($1\frac{1}{4}$") diameter, and be otherwise secured as directed, placed so as to stand 20 inches over the top of the pier, and have the ballast around them well packed.

The west end of the north pier is either to be sheeted anew or the present 6-inch oak sheeting repaired as may be directed, and repairs or renewals of a like nature must be made at the other ends of the piers, if ordered, and to which the respective prices stated in the tender for oak plank and pressed spikes are to apply and be a payment in full for the removal of the old materials, as well as placing and securing the new materials used in the work.

Where the old superstructure has to be removed through what is called the "beach," all sand and rubbish for a space of two feet in width at bottom and to a slope of one to one, must be removed. This material must again be replaced as soon as the progress of the works will admit, the removal and replacing of which will be paid for at the respective rates stated in the tender.

The outer faces of the superstructure of the new work, from the top to low-water line, must be hewn down neatly to lines corresponding to its position, and everything done that may be required to leave the whole in a finished and satisfactory condition.

It is to be clearly and distinctly understood that the prices tendered for the different kinds of materials and workmanship are to be applied either to the renewal or to the repairs of any part, small or otherwise, of the superstructure of the pier on either or both sides of the channel that the contractor may be called upon to execute by the Department of Public Works.

All materials used in the works must be of the best class of their respective kinds, and the prices tendered for the different items of work must cover the entire cost of procuring materials, tools, vessels, scows and labor, providing service ground and every contingency connected directly or indirectly with the prosecution of the work, which, throughout, must be executed in a substantial and workmanlike manner, agreeably to the plan contemplated in the foregoing specification and the instruction of the officer in charge.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in making arrangements for those purposes, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty. He must further use every precaution to guard against interrupting, impeding or in any way interfering with the

navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such may result from a desire to prosecute the works, inattention or any other cause.

Payments will be made at intervals, according to the comparative value of the work done, on a certificate from the officer in charge that the materials are of a proper class and that the work has been faithfully performed; but no advance will be made on materials until they are in the work, and *ten* per cent. on the progress estimates will be retained until the final completion of the contract.

The works are to be commenced immediately after the person whose "tender" has been accepted shall have entered into contract with the Department of Public Works, and must be proceeded with in such a manner as to ensure the completion of the whole by the 1st day of December, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 15th, August, 1879.

APPENDIX No. 28.

SPECIFICATION

For Engines, Machinery and Hull, for a Chain Tug.

This submerged Chain Tug to be on the same principle as that built for the Montreal Harbour Trust; but the hull to be longer and wider, with diagonal trussing the whole length of hull, and to be provided with cabin room on the upper deck for the accommodation of the officers and men. The engines are also to be condensing in place of high pressure, for the economizing of fuel, and the boat to be fitted with hauling-engines for the purpose of taking in and reeling the tow-line.

DETAILS.

Engines.

To have two cylinders twenty-two inches (22) diameter by five feet (5) stroke of piston.

These cylinders to be of cast iron, cast of a mixture of scrap and pig iron, as hard as can be well bored.

These cylinders to be bored perfectly round and parallel, and when bored to be entirely free from blow-holes or spongy spots.

Each cylinder to be furnished with a pair of valve slides, working on valve faces, planed and scraped to perfectly steam-tight faces, and the valves themselves to be planed on their faces and four sides, and to be be scraped up to perfectly steam-tight surfaces on their working faces.

Adams'" rings.

The steam pressure to be removed from the slide valves by "Adams'" rings, which are to be fitted into suitable turned recesses in the back of each valve.

Valve chests.

The valve chests to be circular in form, of the necessary depth and thickness, and to be furnished at each of the outer ends with brass stuffing boxes and brass packing glands finished bright.

APPENDIX No. 29.

RIVER ST. LAWRENCE.

SPECIFICATIONS of Works to be done for the improvement of the CHANNEL through GALOPS RAPID.

The works for which tenders are invited consist of deepening, widening and otherwise forming a nearly straight channel through that part of the Galops Rapid from a point abreast of the extreme upper end of the entrance pier to the Galops Canal, and extending downward to deep water below the bar or to opposite what is called Coldspring Bay on the line indicated in red on the plan.

To effect this object the operations must throughout be conducted in an unusually rapid current, which at some places runs obliquely across the contemplated line of improvements. Besides, interruptions are almost certain to be experienced from the passage of both upward and downward-bound vessels, and large rafts of timber descending, especially such of them as are not under proper control.

Parties intending to tender for the works are especially requested to bear these facts in mind, and they are hereby further informed that they are expected to visit the locality before tendering. Moreover, it is fully believed that persons who have not hitherto given their attention to the subaqueous excavation of rock and other hard material, or are unfamiliar with conducting works in rapid, turbulent, cross or oblique currents in an immense body of water, would consult their own interest by not tendering for this unusually difficult undertaking.

The channel is to be made 200 feet in width, with side slopes of three to one, and the extreme distance within which deepening or widening has to be done is about five-eighths of a mile; for fully one half of this distance in the aggregate work at several detached places will be necessary. Between the bars and shoals there are generally deep depressions in the bed of the river of sufficient dimensions to contain the greater part, if not all, of the materials that have to be removed, provided it be properly distributed.

The bottom of the channel at all places except that part through Island Shoal and the Lower Bar, is to be made so as to have a depth of 16 feet of water over it at a time when there is 9 feet of water on the mitre sill of the guard lock of the Galops Canal.

Through Island Shoal and the Lower Bar the bottom is to be sunk one foot lower than at other places, otherwise the respective depths will be 7 and 8 feet below the mitre sill of the guard lock; this is of course in addition to the surface declivity of the water of the rapid under the level of the canal entrance at a time when there is 9 feet on the mitre sill of the guard lock.

There are six different places within the distance previously mentioned, where excavation has to be done in order to obtain the necessary depths and width of channel. They are situated in descending order as follows:—

1st. The Upper Bar extends from the pier head at the entrance of the Galops Canal to Adams' Island. It is generally one foot higher than the required level of the bottom, but within the line of the channel for a distance of about 250 feet it stands from one to five feet higher than the contemplated bottom. This shoal consists of rock with scattered boulders over it.

2nd. The outer or northern rough margin of what is called the Eddy Reef, at the foot of Adams' Island, has to be removed in order to straighten the channel. It consists for the most part of an accumulation of boulder stones held together by hard material overlying, it is believed, similar rock to that which at other places is found to form the bed of the river.

3rd. The south point of what is termed the North Shoal, right abreast of the guard lock, has also to be removed. It is fully 120 feet long in line of channel and from 5 to 25 feet in width; the greatest depth of cutting is about 5 feet, which is chiefly if not wholly of rock.

Contractors should bear in mind that at this place and at the Upper Bar, opposite the immediate entrance to the canal, the operations connected with deepening, widening and improving the channel will unavoidably be subject to frequent interruptions from the passing of vessels and more particularly from the passing of large rafts of timber which sometimes become unmanageable and occupy the greater part of the channel.

4th. The north point of the South Shoal directly opposite that on the north side of the channel presents an abrupt, rocky face that at a few prominent places has to be removed and the channel in their vicinity made to the depth previously stated.

5th. The Island Shoal extends entirely across the proposed channel, and is from 250 to 350 feet in length, parallel with the river, all of which will have to be lowered from 5 to 7 feet to give a depth of 17 feet at ordinary low water. This shoal, like most of the others, is hard, irregularly-stratified rock.

6th. The Lower Bar is a continuous ledge of rock that extends from the north shore of the river to what is known as Capstan Point, on Galops Island. It is from 550 to 600 feet in length, in line of the proposed channel, and will require to be lowered from 4 to 7 feet at low water, or at a time when there is 9 feet of water on the mitre sill of the guard lock.

At this place, the swiftness of the current and turbulence of the water will render the operations unusually difficult, and, without great watchfulness and care, they will doubtless be even hazardous.

As already stated, there are generally, below or between the respective bars, stretches of water sufficiently deep to contain the bulk, if not all, of the materials that have to be removed. It is thought that after the materials have been sufficiently loosened by blasting, they may for the most part be dragged into deep water by heavy rakes attached to the chain vessel subsequently mentioned, or in such other way as may be found suitable when the works are in progress; provided always that the top parts of the material when in place are kept at least two feet below the bottom of the cuttings; but the top of the material placed below the Lower Bar must be at least three feet under the bottom of the cutting.

From the trials by drilling and otherwise that have been made, it is believed, as before stated, that the bulk of the materials necessary to be removed to obtain the full depth and width of the proposed channel consists of a very hard class of irregularly-stratified limestone, over which there are, at several places, boulder stones embedded in indurated clay and cemented gravel.

When the works are in progress, it is to be clearly understood that the material, after it has been loosened by blasting or otherwise, must be removed as soon as possible, especially if any part of the rock is forced up higher than the present bottom.

To be certain of this course being strictly carried out, no more material is to be loosened or displaced by blasting at one time during the season of navigation than the contractor has the means of fully removing within three hours after each explosion to a depth of at least that of the adjoining parts of the bottom.

This indispensable course, together with the disposing of the loosened materials from the Lower Bar and Island Shoal in the deep water below these places, renders it also necessary that the operations should be commenced at the down-stream end of where the deepening has to be done, to secure the assistance of the current in clearing away the debris or light parts of the loosened materials.

It is further believed that the moorings and the chain, as at present laid down, are favorable for commencing and proceeding in this way.

All the operations must be conducted in such a manner as to occupy at all times the least possible width of the water-way, especially where they are at or near the present navigable channel.

Moreover, it must be clearly and distinctly understood that the channel now used by vessels in passing through the rapid shall not be in any way obstructed during the prosecution of the works.

As this special condition could not consistently be applied to the removal of the Upper Bar, unless under such arrangements as it would be extremely difficult to effect and very uncertain of execution, it is to be fully and distinctly understood that all the works connected with the removal of the Upper Bar must be done between the closing of navigation one season and the opening of it the following spring.

In order to be made aware of the movement of vessels and rafts in the vicinity of the rapids, and thereby be able to regulate, to some extent, the working operations, the contractor will be expected to make arrangements to receive by telegraph, from some place near Prescott such as Windmill Point, the time when vessels downward bound pass that place, and when rafts of timber leave or pass it. He might also be informed from Morrisburg or the Village of Iroquois, when an upward-bound vessel passes either of these places. The notices thus received might be communicated to those on board the

vessels employed in the channel by signals from a house at the guard lock, or some other prominent place on the shore in that neighborhood.

Explanations have been given as to what is contemplated to be done, and attention drawn to some of the difficulties certain to be met with in effecting the object, while others will naturally present themselves to a shrewd, experienced contractor. It is, however, believed that none of them are of a nature which cannot be successfully met by determination and skilful arrangements judiciously made for that purpose.

The deepening, widening and formation of the channel is to be let by the cubic yard of the material removed, to give the actual width and the respective depths before stated. the whole of which, whatever its nature or character may be, it is to be clearly and distinctly understood, will be measured, estimated and computed in the solid, and be paid for at one uniform rate.

For this purpose, careful soundings were taken in the autumn of 1876, at a favorable stage of the river and reduced to a datum line corresponding to the declivity of the surface, with a depth of 9 feet of water on the mitre sill of the guard lock.

These soundings will be checked over the whole area to be deepened and widened, and, where necessary, they will be corrected as the works progress and be referred to a fixed and permanent bench mark.

Duplicate copies of the sections made from these soundings will from time to time be prepared, one of which will be placed on record in the office of the Department of Public Works, and the other remain with the officer in charge.

From these documents, after it has been fully ascertained that the different places have been excavated or otherwise made to the width and sunk to the respective depths contemplated, the extent of work done and for which the contractor is entitled to be paid will be computed.

The deepening and improvement of the channel through this rapid being looked upon as an undertaking of an unusually difficult nature, requiring not only energy, but practical knowledge and skill, contractors are requested to bear in mind that, to entitle a tender to full consideration, it must be accompanied by a paper signed by the party, giving a moderately-full description of the mode proposed to be adopted in accomplishing the object. This is deemed necessary in order to be able to form an opinion as to the capability of the tenderer for the full and satisfactory execution of the work.

To enable a proper examination to be made of this rapid, with a view of ascertaining the nature and extent of the obstructions that will have to be removed or otherwise overcome, a chain vessel of sufficient power for that service was built and fitted up in 1876. The same season a chain was laid through the rapid, and the vessel placed in position, brought into use, and continued until the approach of winter, when it was hauled off and taken to Prescott, where it now remains.

The vessel is 112 feet in length, 27 feet breadth of beam, and draws about five feet water with fuel on board ; it is built in the most substantial manner, with double frames of white oak timber, and fastened in every way likely to give strength and security. The engines are high pressure and condensing, with two cylinders of 22 inches diameter and five feet stroke ; they are built unusually strong, and fitted up with all the latest improvements and equipments.

The two boilers with which it is supplied are of the best description of material and workmanship, and of ample capacity for supplying all the steam required for the engines, drills and other purposes. It is provided with six anchor timbers or "spuds," with gearings for working them when required; four steam (percussion) drills have been fitted up in connection with the spuds on the forward part of the vessel, and there is sufficient accommodation on board for at least 18 men.

The chain on which the vessel works when in position is made fast at the lower end of Adam's Island and is extended downwards through the rapid. It was made to order, with links of a special length to work over sprockets; it is of the very best description of $1\frac{1}{4}$-inch iron, and was properly tested before it was delivered.

At first there was a vast deal of trouble experienced in getting the chain and vessel into position, arising in a great measure from a desire, not only of having the chain laid straight, but of having it as tight as possible and made fast at both ends. It was, however, subsequently found that, by leaving the lower end of it loose, the vessel could readily be controlled in the rapid with the assistance of a small tender alongside, and that it could be anchored where required, and in swift parts of the current remained quite steady. On line of the proposed channel a number of holes were drilled several feet into the rock; still it is proper to state that the season of navigation was nearly closed before arrangements could be made to commence drilling operations, and there being no skilled workmen on hand for that purpose only a few trials were made.

These experiments were, however, favorable, and the means of controlling the vessel being satisfactory, there seems to be no reason now to apprehend difficulties which cannot be successfully met, especially in view of the improvements which can be readily made in the arrangements for effecting the contemplated objects.

The vessel and its equipments, together with the chain on which it works, the contractor will be allowed to use on such conditions as will secure their safety, and at such a rate per month during the time they are used as stated in the tender upon which the contract is awarded.

Contractors are invited to examine the vessel where it is now moored at Prescott, not necessarily with a view to carrying on drilling operations on board of it, but with a view to its use as a means of controlling, placing and keeping in position such vessels, machinery or other equipments as may be employed for any purpose connected with the works when in progress.

The contractor to take the vessel at the place where it is now moored and in the condition it now is, do all such repairs as may be required to it, all of which, together with taking it to the place where it is to be used, placing it on the chain, working it and taking every precaution to guard and protect it, must be done at his own (the contractor's) sole cost and expense.

He must, further, at the close of each working season, take the vessel to a place of safety, keep watchmen upon it, and do everything necessary to protect the vessel and its equipments from injury, in like manner as a careful and prudent man would do with his own individual property.

It may here be stated that no objections will be made to the contractor removing the cabin and upper works, changing the drilling arrangements or introducing a steel sprocket-wheel in place of the present chain barrels, if any or all of these changes are considered desirable. No change or alteration, however, is to be made to any part of the vessel or to

any of its equipments without the sanction of the Chief Engineer of the Department of Public Works being first obtained.

The contractor should also bear in mind that all repairs that may be required, as well as any alterations that may be permitted to be made to the vessel or anything connected with it, together with its full and satisfactory maintenance, must all be done by and at the cost and expense of the contractor, who will, in every respect, be held liable for their safety and efficiency from the day the contract is signed until the final and full completion of the works and the delivery of the vessel and its equipments in such a place of safety as the Department of Public Works may determine. The vessel to be returned in a good condition and state of repair and in every respect as well equipped and furnished as when handed over to the contractor.

It is to be distinctly understood that an officer in the service of the Department of Public Works is to remain on either the chain vessel or on some other vessel connected with the works, and be provided with a berth and board by the contractors during the working season for the whole time the operations are in progress.

Before the chain vessel or any of its equipments are handed over or placed in any way under the control of the contractor, he must insure the same in favor of the Minister of Public Works for the sum of *thirty-five thousand dollars*, in the office of some Canadian or English Insurance Company approved by the Department of Public Works, and the insurance must be renewed and continued until the full and satisfactory completion of a channel of the dimensions contemplated in this specification.

To enable the line and position of the channel to be determined at any place within it, two range marks are to be placed on the shore in continuation of the centre line on both the up-stream and down-stream sides. The upper range to be placed a little west of Boulton's Point, in the most advantageous position that can be selected; one in the low ground lying along the margin of the river, the other on high ground further to the west.

The lower range is to be on Galops Island—one of them on what is called Tripod Point, and the other on the high ground on the south-east side of Rolling Bay.

These range marks are to be made of a triangular form at the base; the mast of the lower mark to be 45 feet high and supported up to the height of 20 feet from all sides of the triangle; the centre posts of those on the high ground to be 40 feet high, supported to the height of 30 feet with braces from all sides of the respective triangles, the braces to be supported by others starting from the foot of the posts.

Foundations to be of cedar posts at least 16 inches diameter, let five feet into the ground and, if the soil is of a soft nature, the posts must be framed to sub sills and braced.

The tops of the posts are to be tenonned into the main sills and be fastened with pins and bolts. The masts are to be of pine timber 12 inches square; the braces also to be pine from 6″ x 12″ to 10″ x 12″ scantling, according to the place they are to occupy.

The masts, braces and sills are to be framed, bolted together and strapped with iron; battens from 6 to 8 inches wide and 1½ inches thick, are to be spiked on the face side of each of the marks, and, near the top of each mast, a disc of heavy tin is to be fastened, and everything done as indicated on the plan.

All the materials used must be of the best description, and those over the surface of the ground must be dressed with a plane and painted with three coats of white lead and linseed oil; color to be subsequently determined.

Where the continuation of the centre line of the channel passes over woodland, such as that on Galops Island, the contractor must cut an opening of such a width that shall leave a clear space of fifty feet between the top of the trees that are left standing.

The providing of all materials, digging and forming foundation and fitting up the four range marks complete, as above stated; together with all chopping and clearing required on the centre line, must be tendered for in one bulk sum.

The preparation and fitting up of the range marks must be proceeded with immediately after the work has been awarded and a contract entered into.

Contractors are requested to bear in mind that tenders are invited, not only for a channel of the width and depth stated in the foregoing specification, but also for making a channel on the line described and of a like width (200 feet at bottom), but with two feet less depth of water; otherwise, with 15 feet of water on the Island Shoal and Lower Bar, and 14 feet at other places in the channel, at a time when there is nine feet of water on the mitre sill of the guard lock.

The contractor must provide, at his own cost and expense, all the service ground that may be required for the placing and preparing of materials or plant, the erection of storehouses, workshops, temporary roads, or for any purpose whatsoever that may be required outside the canal lands in the vicinity. He must also secure the right to erect the range marks on the north shore of the river as well as for those on Galops Island.

No magazine in which there is over fifty pounds weight of explosive substances will be allowed at any place within a distance of one mile of the navigable channel of the river, nor within one mile of the Galops Canal.

The contractor must conduct the operations in such a manner as not in any way to interfere with the passing of vessels, or the passing of rafts of timber.

It is further to be clearly understood that in case of any alteration in the position of the chain moorings, or of the chain itself, being required for the advantageous prosecution of the works, at any place where the deepening or widening of the channel has to be done, the alteration must be made by the contractor, at his cost and expense, subject as to position and in every other respect to the approval of the Department of Public Works.

It is possible that the chain, as now moored, may suit the works on the Lower Bar, and Island Shoal, but there is no certainty of this being the case. It is, however, certain that the chain will have to be moored at a different place from where it is at present, to be serviceable for the deepening of the Upper Bar, or when removing the point of the reef at the foot of Adams' Island, etc.

The prices tendered for the different parts of the works must include all necessary vessels, tugs, scows, boats and their equipment, chain moorings, alterations to position of chain, transport, service ground, telegraph stations and service, deepening and widening channel and removing of material, and all the necessary work described in the foregoing specification.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and the place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the work embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract,and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 1st day of June, 1881.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 27th August, 1878.

APPENDIX No. 30.

EXTRACT FROM THE REPORT OF THE CHIEF ENGINEER OF PUBLIC WORKS, ON THE NAVIGATION OF THE RIVER ST. LAWRENCE BETWEEN LAKE ONTARIO AND MONTREAL, DATED 9TH JULY, 1874.

WILLIAMSBURG CANALS.

These canals are situated on the north shore of the river, and were constructed chiefly to overcome the Galops and other rapids of less descent, together with certain stretches of swift water, all of which will be subsequently referred to.

They have been formed by cutting through projecting points, and with the material removed, enclosing bays and indents in the shore-line so as to make in each case a continous range of bank between the river and the canal.

Where the current is strong and the water deep or wherever required by circumstances, the banks have been kept in place by a line of rough crib work, and along the outer side, as well as at other places where necessary, they are for the most part protected with a facing of stone.

In thorough cutting the channel was made fifty feet wide at bottom, with side slopes of two horizontal to one vertical.

The locks are of a good class of dressed stone masonry, in a fair state of repair; they are 200 feet long between the gates and forty-five feet wide.

Although collectively called the Williamsburg Canals, they are situated in three different counties (Stormont, Dundas and Grenville), and, being considerable distances apart, are really in three divisions, and may, together with their relative positions, be briefly described as follows :—

The first of the series in ascending order is known as Farran's Point Canal, which commences at the head of what is called Big Eddy, near the rapids in the north channel, or about four and three-quarter miles above the upper end of the Cornwall Canal.

In that part of the river, between these places, there is a sufficient depth of water for vessels of the largest class, and the surface declivity is only six-tenths of a foot; but in the bay or eddy above mentioned there is a cross and irregular current very perplexing to those unacquainted with its peculiar action; this, a few years ago, was

especially the case in the vicinity of the lock ; but the entrance has been much improved by the construction of a pier on the outer or river side, which has had the effect of changing, to some extent, the northern part of the current.

The canal is about three-fourths of a mile long, with a depth of not more than seven and a half feet at extreme low water ; it was formed chiefly by cutting into the outer edge of the bank on the north-west side of the river, which at this place varies from fifteen to thirty-eight feet in height over the water surface.

The lock has a lift of three and a half feet, and on its lower sill, during the year 1872, there was frequently not more than seven feet nine inches of water.

It will therefore be evident that the bottom of the reach must be lowered fully five feet, and made of such a width as will admit two of the large class of vessels passing each other freely, and that the lock must either be taken down and rebuilt, or a new one constructed in another position in that vicinity.

But there is reason to believe that no other location for a lock in that neighborhood could be judiciously selected, so that the rebuilding of the present one will be unavoidable, unless the suggestions subsequently brought under notice be considered worthy of adoption either in part or as a whole, in which case it is probable that the lengthening of the lock may be deemed sufficient.

The upper entrance of this canal is so situated that the south side of a shoal, which runs obliquely out from the landward side, is at 300 feet above the pier in line with the south side of the channel, and a little higher up it extends a considerable distance beyond, that line.

To the southward of the immediate entrance the current is fully three and a half miles per hour, and continues at this rate up to near the foot of Cat Island.

Taking down the lock and constructing a new one of the dimensions proposed deepening channel, and enlarging it to eighty feet bottom width, and improving the upper entrance, would probably cost $320,000.

From the upper end of this canal to the foot of Rapide Plat, a distance of ten and a quarter miles, the surface inclination is about 8·29 feet, and through that part of the channel below Cat Island, and north of Sturgeon Point Shoal, on the American shore, the current, as previously stated, is about three and a half miles per hour. Thence for about two miles, to "Pillars," the channel is straight and the water is comparatively still ; above this, to opposite Chrysler's farm, the current is strong in the line of deep water, and navigation is rendered difficult by extensive boulder flats, known as Casselman's Shoals. These extend out a considerable distance from the north shore, causing vessels to cross and recross the current, and ultimately take a circuitous route on the American side to the foot of Goose Neck Island. The channel then follows along the north side of this Island for nearly a mile, when vessels have to cross over towards the "Churches" on the north shore (about two and a half miles below Morrisburg); they then continue on that side between the shore and Willard's Shoal up to the foot of Rapide Plat.

It should, however, be stated that at periods of low water a series of shoals, which extend out from the north shore, force vessels out into the stong current, and sometimes necessitate their crossing over to near Monk's Island before reaching the canal.

The second division is Rapide Plat Canal, which is about three and three-quarter miles in length, and the difference of level between the water at its upper and lower ends is nearly eleven and a half feet. This elevation is overcome by a lift lock at the outlet at Morrisburg, and near the upper end is a guard lock at which the head of water varies from nothing to four feet, and at periods of extreme low water, such as occasionally occurred in 1872, it was fully two feet lower than would allow vessels drawing nine feet water to pass through the canal. The summit level in this case extends to the outlet lock, which renders necessary the deepening of the entire canal fully five and a half feet; and the widening of it to about eighty feet at bottom will also be required to admit of two vessels passing each other freely.

By taking advantage of several bays on the line, and widening out where practicable on the south side, together with enlarging the channel above the guard lock to a width of 100 feet, and a depth of not less than thirteen feet below extreme low-water line, would require the removal of about 1,040,000 cubic yards of material.

In October, 1872, there was, for a time, only seven feet water on the sill of the outlet lock, which shows that the present foundation is fully five feet higher than it should be for the proposed scale of navigation; consequently, if the same line was continued, the whole would have to be removed and rebuilt at a lower level.

It is, however, deemed proper to state that a new structure might be advantageously placed on the south side of the existing one, whether viewed in connection with the approach to it from above or the entrance to it from below.

The overhauling of the present lock and building another structure in the same position would, of course, have to be done between the closing of navigation one year and the opening of it the following spring; whereas an entirely new lock might be built during the summer when a better class of work could be done at very little, if any more expense than would be required to effect a similar object under the most favorable circumstances in the winter or spring months. Moreover there would be no risk from the breaking of coffer dams, unwatering of works or any other probable cause that might retard the operations and thereby lead to delay in opening navigation or of otherwise interfering with it, a state of matters, it is believed, that would fully warrant, if need be, some additional expenditure.

In October, 1872, the river was so low that there was only six feet seven inches of water on the sills of the guard lock, clearly establishing the fact that the bottom will have to be lowered about five and a half feet to secure a depth of twelve feet at low water.

This, it is scarcely necessary to say, implies the taking down of the entire structure or the building of a new lock in some other position.

On both these points the remarks above made relative to the outlet lock are no less applicable in this case, except that the new lock would have to be on the north side of the present one.

If entirely new locks are built, the present one at the upper end could be used as a supply weir, and that at the lower end be converted into a waste or regulating weir. At all events some provision must be made for both these purposes, and by adopting the course indicated the expense might be fairly credited to the construction of new locks.

The probable cost of enlarging Rapide Plat Canal to the width of eighty feet at bottom and a depth of 13 feet in the reaches, construction of new locks and forming

the present ones into supply or regulating weirs, rebuilding entrance piers, etc., would be about $820,000.

The rapid which this canal was constructed to overcome is about 3¾ miles long and has a declivity of about eleven and a half feet, and the channel through it is deep, so that vessels drawing twelve feet may use it safely at any stage of the water.

From the head of Rapide Plat Canal to Point Iroquois the distance is a little over four miles, with a deep channel throughout, uninterrupted by shoals and comparatively straight, with a surface inclination of three and a half feet.

Ascending vessels generally keep near the north shore for a distance of two miles to opposite Pine Tree Point, which is said to be the narrowest part of the River St. Lawrence.

In this vicinity there are no bays or indents in the shore line of any considerable extent, so that vessels are forced out into the current and frequently cross the river three times within a stretch of little more than half a mile, and then follow along the south shore one and a half miles to Point Rockaway, thence cross over to the bay at the lower entrance of Iroquois Canal. There is, however, no real necessity for crossing the river, as the channel from Pine Tree Point upwards to the entrance lock at Iroquois is both deep and wide, and as a whole favorable to vessels either ascending or descending.

The third division embraces what was formerly the Iroquois and Galops Canal, which were at first separated by a considerable stretch of river, but were subsequently joined by a bank forming what is now called the Junction Canal. They now form one continuous line of about seven and a half miles in length, with a fall of 14·81 feet, and are collectively known as the Galops Canal.

The Iroquois section is two and nine-tenth miles long, about one mile of which is through rock, where the cutting varies from one to ten feet in height, the deep portion, however, is not more than one-fifth of a mile in length.

By the junction of the Galops and Iroquois section the water was raised nearly two feet, so that there is now a depth of 12 feet throughout this portion of the canal. It has a bottom width of fifty feet in all thorough cuts, with side slopes in clay of two horizontal to one vertical, and in rock of a quarter to one; towards the upper end of it there are a few stretches of wide but shoal water.

The probable quantity of material to be removed to afford a bottom width of eighty feet and a depth of thirteen feet would be about 270,500 cubic yards of clay, and 62,000 cubic yards of rock.

The junction section is nearly two and a half miles long, and consists chiefly of an embankment formed on the outer or river side, so arranged as to have a sufficient water space inside and connect the two portions of the canals above mentioned.

The material for that purpose was chiefly taken from two thorough cuts, one situated about the middle and the other near the upper end of the line; between these points there are several long stretches of wide and in some places of deep water.

There are, however, at present only a few isolated places where the water exceeds 10½ feet, so that the bottom for the most part must be lowered fully two feet and the width of the thorough cuts increased to at least eighty feet at bottom.

To do this will require the removal of 233,000 cubic yards of material, chiefly clay, but above Presqu' Isle the bottom at several places consists of boulder stone.

The Galops section proper is about $2\frac{1}{8}$ miles in length from the lower end of the lift lock at Point Cardinal to the upper entrance which is in line with the lower ends of Boulton's and Adams' Islands, situated about seven miles below Prescott and a short distance above the head of the Galops Rapids. Its course at the inlet bears directly towards the north side of Munroe's Bay, and over certain boulder shoals on which there is a strong cross current, and where considerable difficulty will be experienced in forming a channel of the necessary depth.

The upper end is much exposed to the action of moving ice when the river opens in the spring, and, from its being of timber pier work, is expensive to maintain.

From the entrance downwards, the embankment which forms the south side of the canal follows closely along the margin of the river, and was doubtless made up of the material excavated from the prominent points, sloping side banks, etc., through which the channel was cut in order to diminish the curvature ; nevertheless, the line is unusually tortuous.

For a considerable distance at the upper end, in and near the rapids, also where the swift water strikes towards the lower end, the embankment is kept in place and protected by ranges of rough cribs, and the outside at other places has been faced with stone.

As a whole it stands well, a circumstance no doubt due to the peculiar nature of the material of which it is formed, being for the most part a sort of indurated clay that, within a short time after it has been excavated and properly placed, assumes nearly its original compactness.

At periods of extreme low water there is very little more than eight feet on the sills of the guard lock, so that it will be necessary to deepen the channel fully four feet for vessels of the contemplated draught, and to enable them to pass each other freely the width should be increased to 80 feet at bottom.

This would require the removal of 430,000 cubic yards of material, a large portion of which would be of a very hard nature, and at several places boulder stone would be numerous and in some cases large.

It is now proposed to draw attention briefly to each of the three locks, already casually mentioned as on this division.

Lock No. 25, situated at the Village of Iroquois, has now a lift of eight and a quarter feet, and the one at Point Cardinal, No. 26, has a lift of six and a half feet; but the head of water at the guard lock varies with the fluctuations of the river, and there are times when the water above and below the gates is on the same level.

When these two sections of canal were first opened, the water below Lock No. 26 and above No. 25 varied in height with the rise and fall of the river ; but the joining of them has enabled the intermediate level to be maintained at an uniform height, which has been found not only an advantage to navigation, but also to the water power in use at the respective places.

On the sill of the outlet lock (No. 25) at Iroquois, there was in October, 1872, a depth of nine and a quarter feet, or nearly three feet less than required for the proposed scale of navigation.

But as this lock is built on a comparatively flat ledge of rock, there is reason to believe that the chamber and lower recess floor might be cut down sufficiently low to afford the depth required without disturbing the side walls, and that the walls might be advantageously extended from the line of the breast wall upwards.

The rock in the bottom was ascertained to be sound and good in the winter of 1851 and 1852, when the lower recess floor and part of that of the chamber was cut down, and the mitre sill laid at a level fully three feet lower than it was originally.

The adoption of the plan suggested would enable the work to be done for at least from one-third to one-half less than the construction of an entirely new lock.

In this connection it is deemed proper to state that the guard lock (No. 27) at Galops is also built on a rock foundation, which is about four feet over the level required. This, there is equally good reason to believe, might be cut down and the walls secured in like manner as intimated for the lock at Iroquois—the principal difference being the fact that the structure may be lengthened at the end where the foundation is best suited for that purpose.

When constructing the lock at Point Cardinal (No. 26) it is said that the unequal bearing which the material afforded, springs in the bottom, etc., led to considerable difficulty in forming a good foundation and securing it properly.

The present bottom at the sides being about three feet too high for the enlarged scale of navigation, it is to be feared that the lowering of it would in all probability be found equally, if not more troublesome than it was in the first instance to form it, especially as the time for executing the work would unavoidably be limited and confined to the most unfavorable season of the year.

It is therefore proposed to place the enlarged lock immediately on the upstream side of the present one, and on the line best suited for access to it at both ends.

At the place mentioned there is reason to believe a good foundation will be obtained, and the works as a whole be in a favorable position for execution.

The raceway for the supply of water-power, granted in lieu of damages, as well as for that since leased at this place, will doubtless have to be extended, but that will be a small matter compared with the uncertainty and expense of dealing with an unfavorable foundation for the lock.

In carrying out the plan above indicated, the north wall of the old lock might, after the toe is properly secured, be allowed to remain, and the south side be removed, or both walls might be taken down and the best of the stone used in the new work.

To enlarge the Galops Canal, embracing the Junction and Iroquois sections, to a width of eighty feet at bottom, and the depth of thirteen feet throughout; enlarging the outlet lock and guard lock; constructing a new lock at Point Cardinal; improving the upper entrance, etc., etc., would approximately cost..... $970,000

Rapide Plat Canal.....	820,000
Farran's Point Canal.....	320,000
Probable cost of enlarging the Williamsburgh Canals.....	$2,110,000

Descending vessels of moderate draught follow the channel of the river, from the head of the Galops Rapid to near the upper end of the Long Sault Rapids, and ascending passenger steamers take the same channel upwards at ordinary stages of the river.

The time occupied between the places mentioned, by downward-bound vessels, when they follow the channel of the river throughout, is generally about two and a half hours ; but those that are forced to use the canal and the stretches of the river between them, spend at least seven hours between the same places.

Passenger steamers ascending from Dickinson's Landing to the head of the Galops Rapid, keeping altogether in the channel of the river, make the trip in four and a half hours, and those which pass up through the canals and parts of the river between them, occupy generally about six and a half hours, and loaded propellers, bound upwards, require from nine to ten hours between the same places.

These facts clearly point to the conclusion that the carrying trade could scarcely fail to be greatly benefitted if the most expeditious line could be rendered available to all vessels, whether downward or upward bound.

APPENDIX No. 31.

EXTRACT FROM THE REPORT OF THE CHIEF ENGINEER OF PUBLIC WORKS ON THE NAVIGATION OF THE RIVER ST. LAWRENCE BETWEEN LAKE ONTARIO AND MONTREAL, DATED 9TH JULY, 1874.

CORNWALL CANAL.

This was the first constructed, and is the largest of the existing series of what is known as the St. Lawrence Canals. It is about 11½ miles in length, 100 feet wide at bottom and 150 feet at the water surface where formed through cutting; but at all the road culverts under it, and at the swing bridge at Cornwall, the water-way is considerably reduced.

On the line there are six lift locks and a guard lock, built and arranged so as to overcome a difference in the water level of about 48 feet.

The locks are 200 feet in length between the gates, fifty-five feet wide in the chamber, and on the sills throughout there is a depth of nine feet water except at extremely low stages of the river.

At the lower end of the canal three of the locks are so situated that between the one at the immediate outlet (No. 15) and the next in ascending order, the distance is only 331 feet, and the basin between Locks Nos. 16 and 17, is about the same length.

In these short reaches, although they are of considerable width, a good deal of difficulty is at times experienced when two vessels that can freely navigate other portions of the route attempt to pass each other in them.

The lowest water ever observed on the sill of the outlet lock was on 3rd the November, 1872, when it stood for a short time at eight feet eight inches.

From the lower end of this lock (No. 15) to the head of No. 17, the distance is about 1,475 feet, thence to the first road culvert or tunnel 1,000 feet, where the surface width of the canal is 110 feet, and the crown of the arch one inch and a half over the present bottom of the reach, which is generally about one foot under the top of the lower mitre sill of Lock No. 18.

From the tunnel to the swing bridge opposite the town of Cornwall, the distance is 1,900 feet, or from the foot of the lowest lock 4,375 feet.

The opening between the bridge abutments is about fifty-six feet, which is the only means at present of passing the supply for navigation, and the water power leased on

the north side of the channel, which is used for an extensive cotton factory, a large cloth or woollen factory and a grist mill.

At a distance of 250 feet below the tunnel, a regulating weir was a few years ago constructed, over and through which the surplus water can be discharged at times when not otherwise required.

The head gates for passing the supply for water power on the north side of the canal were built by the Government, and still continue, I believe, under the control of this Department. On the south side of the canal, and a short distance above the swing bridge, a grist mill, with other machinery attached, also a saw-mill, have been for many years in operation, and a large cotton factory was recently built, which was only a short time in use when it was destroyed by fire.

On this reach there are water powers leased and granted, estimated to drive thirty-six runs of ordinary mill-stones, which are understood to mean at least 360 nominal horse power, although it is quite probable that considerably more water is used.

From the head of Lock 17, to the lower end of Lock No. 18, the distance is 7,025 feet; about 300 feet from the tail of this lock, Wood's Creek Culvert passes under the canal at such a height that the top of it is three feet two inches below the present bottom.

The supply to this reach passes over and through a weir, built on the north side opposite the head of the lock, thence by a raceway which enters a short distance lower down on the same level as that of the canal. It is, however, found that the position and direction of the strong current thus produced are very objectionable to upward-bound vessels entering the lock.

The reach below Locks 18 and 19 is 7,789 feet in length, and the supply to it is maintained in a similar way to that for the level below, except that the weir is below the lock, and in a position which throws the current more directly across the channel.

Between Locks 19 and 20, the distance is 8,333 feet, and from the head of Lock 19 to the road culvert leading towards Barnhart's Island the distance is about 4,650 feet.

This culvert, like all others intended for a roadway, is twelve feet wide and nine feet high; but in this instance the crown of the arch is about three feet nine inches under present bottom, and the canal is only ninety feet wide at top-water line.

Lock No. 20 is fully four and three-quarter miles above the outlet, and nearly six and three-quarter miles from the light on the pier at the upper entrance.

Water sufficient to drive ten runs of stones has been leased from the level above this lock, only part of which has been brought into use. The balance of the supply required for the Cornwall level, in addition to that passed as above stated, is furnished over and through a weir situated at right angles to the lock, at a place nearly opposite the lower quoins.

From this lock, situated at the foot of the summit level, the line for a distance of fully five miles follows along the margin of the river in a tortuous course, doubtless to avoid as much as possible the projecting high points along the shore.

At several places on this part of the route (in the aggregate probably three-fourths of a mile) there are wide stretches of water-way, some parts of which are of considerable depth.

At about a mile above the lock referred to, the road culvert at Mille Roches passes under the canal, and is of such a length and so arranged as to leave the water-way only 100 feet wide at surface, and the crown of the arch about sixteen inches below the present bottom line. Moulinette Road culvert is situated nearly two miles further up, at which place the canal is 117 feet wide at the water line, and the crown of the arch rises to within fifteen inches of the bottom.

The guard lock is nearly five and three-quarter miles above Lock No. 20, or about one mile below the extreme end of the outer or river pier at the entrance ; it is a composite structure, the ends and recesses for the gates being of dressed stone masonry, and the sides which form the chamber are of timber crib work.

On the landward side of the lock a supply race has been formed twenty eight feet wide at the water surface, and a regulating weir thirty seven feet between the side walls built nearly opposite the lower gates.

The breast wall of the weir is carried up to within about two and a half feet of low-water level, and in it there are six sluice-ways, each four by three feet, which, after deducting the thickness of the respective gates, leave the sluice openings equal to an area of sixty three square feet.

The section of the water-flow over the breast (less the centre pier), being 85 square feet at the time when there are nine feet of water on the lock sills, gives an aggregate area of only 148 square feet for the water to enter when all available means are fully open, or less than one-eighth of the sectional area of the canal.

It will be obvious that this means of admitting the supply must be wholly inadequate to the requirements, when it is borne in mind that at low stages of the river the water above the guard lock is on the same level as that below it and frequently, during some years, the river level is not more than one foot over that of the canal.

In October, 1872, the depth of water on the lock sills was for a short time eight feet three inches, and in October, 1873, it was, one day, eight feet seven inches.

These sills having been placed so as to have nine feet of water over them, it will be evident that, unless the river is higher than to give that depth, there will be no "head" on the guard gates ; consequently the supply cannot be greater than the limited capacity of the weir will admit, with a flow such as may be produced by drawing down the summit level at its lower end.

This fact in 1872 was forcibly brought under the notice of those connected with the navigation as well as the lessees of hydraulic power, the water being then nearly, if not altogether, as low as at any time of which there is a record.

The bottom of this reach, both above and below the guard lock, is only a few inches lower than the top of the present mitre sills, consequently it must be sunk at least four and a half feet to give a depth of one foot below lock sills placed so as to admit of vessels drawing 12 feet to pass freely at low water.

By lowering the bed of the canal, as above stated, and continuing the slopes at a like inclination as at present, the bottom will be diminished to 82 feet, thus rendering it necessary to increase the width 18 feet in order to obtain the dimensions contemplated.

From the general appearance of the south bank, together with what could be learned of its foundation, there is reason to believe that it would be injudicious to interfere with

it in any way. The widening must. therefore, be done altogether on the north side, although the ground is for the most part high and has every indication of being unusually hard.

The material excavated will generally have to be deposited along the outer or river side of the south bank, and the removal of all that portion of it below ordinary water line should be done by powerful dredges or excavators adapted to work in hard material, and such arrangements made that the deepening and widening of the whole can be done without at any time drawing off the water or in any way interfering with the passage of vessels during the season of navigation.

To effect these objects, it is quite probable that a number of movable derricks will have to be constructed and arranged at short distances apart along the south bank, so as to facilitate the operations connected with depositing the excavated material on the outer or river side.

The deepening and widening of the prism of this reach to the contemplated dimensions will require the removal of fully *one million and a quarter* cubic yards of material.

As already stated, the water above and below the guard lock has been frequently on the same level, and for a considerable length of time in seasons of ordinary low water the river is not more than from ten to twelve inches higher than the canal.

These facts clearly point out the necessity of having the supply race as large as possible, and especially of having the regulating weir with as many sluice openings in its breast wall, and such an available width and depth of water-way over it as will, when they are open and clear, admit of the full supply entering freely.

At present the centre line of the lock and that of the canal are nearly the same, so that there is really only one-half of the surface width of the canal for the northern half of the lock, its embankment and the raceway.

It may also be observed that the ground on the landward side is fully forty feet higher than the proposed bottom of the reach.

From the depth which the channel has to be sunk, it will be evident that the guard lock must be taken down and a new one built; at the same time a wider raceway formed and a much larger supply weir constructed.

To admit of this being done, and of the new structures being placed in nearly the same position as the present ones, the water would have to be drawn off for one full winter, a state of matters that should, if possible, be avoided, as it would involve the stoppage of all the mills and factories at Cornwall, and thereby throw a great number of persons out of employment.

By the selection of another site for the lock and weir, this unfavorable result, it is believed, might be entirely avoided, a better class of work secured, and the outlay very little, if any, increased.

There is, however, good reason to believe that any place much below the present structures could not judiciously be chosen for that purpose, as the present water-level of the canal is several feet higher than that of the river immediately opposite, whilst the bank between them is of a nature unlikely to retain the water if the level of high stages of the river were extended further downwards.

Although, as previously stated, the river and canal are for short periods at irregular intervals on the same level, there are times of much greater length when the former is several feet higher than the latter. At these times the difference between the canal below the guard lock and that part of the river opposite is really less than at low water, the long reach being generally maintained at an uniform height by the regulating weir.

This condition of matters would, however, be entirely changed by placing the guard lock lower down, as the high water level would then be extended along a part of the bank where, in the first instance, great difficulty is said to have been experienced in making it tight even at the lower level.

It is therefore believed that whatever advantages could be gained from a more easterly position for the guard lock, they are more than counterbalanced by the risk connected with raising the water on an uncertain portion of the bank.

To meet the case in what is believed to be the least objectionable way, it is proposed to place the new guard lock about a quarter of a mile above the present one, and in such a position as to be on one side of the centre line.

This arrangement, together with cutting from forty five to fifty feet off the north bank (where there is now within the distance above mentioned a bend in the line of fully more than the width of the present surface water), would give sufficient space for all requirements.

The lock could be placed on either the south or north side of the channel; but if the latter position for it was selected, a bridge would have to be constructed for access to it, —in either case it is believed that the lock can be built during summer, by first cutting off the salient point referred to, and enclosing the necessary space by means of coffer dams arranged so that vessels can pass freely on one side of them.

The regulating weir could be built the following season, and the supply during that time be passed through the lock; otherwise, by having everything required fully prepared, delivered and ready, the weir could be built within a month, at the time when the water is drawn off for spring repairs.

At the upper end of the river bank, a pier of crib work was a few years ago built, extending up stream about 325 feet, which had the effect of greatly improving the entrance, as well as of raising the water, above the guard lock, fully *five inches.*

There is, however, very little declivity in the surface of the river for a long distance above the upper end of the pier, so that its further extension for any reasonable distance would not have the effect of raising the water inside to any appreciable extent; thus clearly pointing to the fact before mentioned that, in order to obtain the contemplated depth of water, the bottom of the upper reach must be lowered.

It is now proposed to draw attention to the lower entrance, as the place where works no less extensive are likely to be required. The locks there being as already stated, only 331 feet apart, the ordinary class of vessels frequently experience considerable delay in passing each other between them. This being the case at present, there can scarcely be a doubt but that the difficulty would be increased were the vessels larger, and still more so if the length of the reaches were at the same time diminished.

The latter evidently must be the result on one or both of these reaches, if seventy feet be added to the length of each of the existing locks, no matter to which end the addition is made.

It should also be borne in mind that the sills and foundation of the outlet lock, except the centre portion of the chamber floor, are at least three feet too high, the lowering of which, there is good reason to believe, will necessitate the taking down and rebuilding of the whole structure.

This lock cannot judiciously be moved any further out into the river, a fact which leads to the conclusion that to obtain the length of reaches required the other two locks must also be taken down and rebuilt.

Vessels are unable to pass each other freely in reaches of less dimensions than about two and a half times their own length, which, for the class of vessels contemplated, would be a space much greater than could be obtained at anything like a moderate expenditure.

This state of matters does not result altogether from the present relative positions of the locks, but from the fact that an ice jam annually occurs at a short distance below the entrance of the canal, which has the effect of raising the river so that the water at such times passes over the two lower locks.

Under these circumstances it will be evident that the formation and maintenance of such dams as would be necessary to enable the outlet lock to be laid dry would be exceedingly expensive, even if the object could be effected at all between the close of navigation one year and its opening the following spring.

At the times alluded to, the water is not unfrequently raised twenty feet over its ordinary height, and in 1861 it was twenty one feet higher than the September level of the preceding year.

In the year just mentioned, a barrier of ice was formed opposite the town of Cornwall, which had the effect of raising the river so that the water backed up through Woods' Creek Culvert (near Lock No. 18), where it entered the canal and raised what is called the Cornwall level, so that at several places it overflowed the banks. At this time the water in that part of the river alluded to was twenty nine feet above its usual height.

These occurrences clearly indicate that the taking down and rebuilding the lower locks of the Cornwall range, during the winter or early spring months, would be an undertaking attended with difficulties of no ordinary nature; still the bottom of the outlet lock must be lowered, and the relative position of the others must be changed, in order to obtain reaches of the necessary length.

On fully considering the various perplexing matters that would be likely to arise during the enlargement of this portion of the existing line, and the uncertainty of being able to meet them successfully, it was deemed advisable to make a thorough examination of the locality, in order to ascertain whether a new outlet and an independent cut could be advantageously formed, in the course of which it was found that about 300 feet south of the present line there is a place favorably situated for a new entrance, with a good depth of water in the vicinity. It is, at the same time, to some extent sheltered by a slightly projecting point on the up-stream side, which has the effect of throwing the current outwards and creating a sort of eddy, that renders it fully as accessible as any other place in that locality.

From it a line could be continued upwards, nearly parallel to the present range of locks, to a short distance beyond the road culvert before mentioned, in the neighborhood of which the new and old portions of the route would unite. In the execution of this plan, the difference of level between the river and Cornwall reach might be overcome by

means of two locks, an arrangement that would admit of the intermediate reach being made of such a length as might be required.

By the adoption of this plan the preparation of the foundations and laying of the lock masonry could be done during the summer, when the work would doubtless be better, and could be more economically carried out than at any other season of the year.

It would also obviate the necessity of emptying the canal, or in any way interfering with the extensive water powers in operation there.

The lower terminus would, there is good reason to believe, be in fully as good a position for the entrance or exit of vessels as the present one, besides there is a projecting point lying to the north of it that could be raised and secured in such a manner as would, to a great extent, protect it from the effects of ice when the annual blocking up of the river takes place.

This plan of course would involve the necessity of purchasing all the block of land lying between the canal and the river, or about thirty-four acres, the acquirement of which would, however, fully warrant the closing up of the road culvert if considered better than to extend it farther to the south.

The present waste weir would also have to be taken down and another built in a suitable position for the new channel, otherwise the old locks might be converted into regulating weirs, and the channel into a raceway, which, under the circumstances, would probably be the best use that could be made of them.

Experience acquired from the recurrence of the phenomenon above referred to has led to the removal of the upper works connected with the outlet lock, and to fastening the gates back in the recesses, after the close of navigation each year ; but as the lift is only from six to eight feet, there are seldom, even at such times, less than three feet of water in the reach above, or sufficient to prevent any serions scour on the bottom.

At the new entrance lock, although the probability of damage from ice would be much less, it is quite likely that a similar course to that alluded to would have to be adopted, and as the lift would be about equal to the depth of the canal, the reach at such times would be entirely emptied.

To guard against this, it is proposed, when required, to place such a number of stop timbers over the breast wall of the lock as will maintain a depth of from three to four feet in the reach. These timbers to be put in in December and removed early the following spring.

To purchase the land lying between the river and the canal, forming and protecting a new entrance channel, constructing two new locks and a regulating weir, lengthening out the road culvert or the entire removal of the present structure, forming a connection between the new and old portions of the line, protections of banks, etc., would cost about $530,000.

To obtain the necessary depth of water in the Cornwall reach, and also in that between Locks Nos. 18 and 19, it is proposed to raise the level in both cases about three feet, instead of attempting to lower the bottom, as the latter would necessitate increasing the width also.

It is believed that the securing, raising, widening and protection required to the banks, by raising the water, would barely cost one-half the amount that would be necessary to deepen and enlarge the prism.

There is also reason to believe that it would be found so advantageous to lessees, especially during the time of back-water, that they would scarcely hesitate to raise their flumes, races and head gates to the proper height, at their own expense.

In adopting this course no apprehension need be entertained of any interference with private or other property in the vicinity.

It may further be stated that by raising these levels, the bottoms of Locks 18 and 19 would be sufficiently low for the enlarged scale of navigation, so that an addition to the foundation floor, such as would admit of the side walls being made of the full length, would, together with increasing their height throughout, enable the object to be effected.

There are, however, several objections to this plan, some of which may be stated as follows:

1st. The present walls are not in a very good state of repair, arising, in part, from the failure of some of the stones, but chiefly from the class of mortar used in their construction.

2nd. The locks are 55 feet in width and must remain so if the walls are only made longer and higher, which would necessitate a heavier class of gates, require a longer time to fill and empty than a lock 45 feet wide, and that too without possessing any advantage whatever.

3rd. The work would have to be done in the winter and early spring months, when even at a much greater outlay, it could not be so well executed; besides, in order to effect the object the canal would have to be emptied, which would throw all those dependent upon the water power out of employment.

On considering these various matters, the question naturally presents itself: Can they be met in such a way as to lessen the difficulties, within the limits of a moderate expenditure?

It is doubtless true that the locks are now in the best line and position for the navigation; still others could be built during summer where they would be equally as accessible, after suitable approaches to them have been made.

They could be placed on the north side of the existing structures, nearly in line of the raceways, at least expense; but the selection of any position on that side would render it necessary to build and maintain a bridge at both ends of each lock, so as to form a continuous towing path. This plan, of course, assumes that the present small supply weirs would be dispensed with, and that the old locks would be used solely for the purpose of regulating the water levels.

By placing the new locks on the south side of those now in use, a considerably greater quantity of excavation would have to be done, some high embankments formed and protected, but the expense and inconvenience of towing path bridges would be avoided.

The work in either case could be done at the most favorable season of the year for such operations, and what is of at least equal importance, without drawing off the water or interfering with navigation.

In short, by adopting the plan of building entirely new locks, they could be made of uniform dimensions, the work better executed, and most, if not all, the objections above enumerated be fully met.

Under the impression that this is the best course to pursue, it may be stated that the examinations made lead to the conclusion that the south side should be selected as a site for Lock No. 18, but Lock No. 19 will, in all probability, have to be placed on the north side.

The contemplated depth and sectional area of the reach between locks Nos. 19 and 20 may be obtained either by raising the level or lowering the bottom and widening the channel, as may be considered best.

By raising the water, the head and fall at lock 20 would be reduced, consequently the mill property there would be depreciated in value, and at several places the lands on the north side would be flooded. On the south side, the banks being at many places high and comparatively narrow, would have to be widened, strengthened and protected, as well as raised.

The arch of the culvert for the road leading to Barnhart's Island is of a height that would admit of lowering the bottom of the channel, but the culvert must in either case be lengthened forty feet at least, to obtain the necessary width of water-way.

On considering the matter fully, it is believed that, in this instance it would be less expensive to deepen the channel than to keep the water permanently at a higher level.

The present lock (No. 20) being situated at a sharp curve in the line, the approaches to it from either direction for vessels of a large class are unfavorable, and of course would be still more so it the lock was lengthened and the size of the vessels increased. This, together with the fact of its being ten feet wider than required, and the foundation too high in case of lowering the bottom of the reach, to give the full draught of water, point to the necessity of having a new lock constructed.

Judging from the general appearance of the ground lying between the canal and the river, the new structure could be placed there in such a position that the line and approaches to it would be improved without incurring much, if any, greater outlay than would be necessary to adapt the present lock to the requirements.

It has been already stated that the bottom of the summit level must be lowered from three and a half to four and a half feet; consequently, the culverts at Mille Roches and at Moulinette, which are only from fifteen to sixteen inches under the present bottom, must be partly taken down, rebuilt and lengthened.

The bottoms of those culverts are already so low that the river backs up into them, whilst the height between the road-way and centre of the soffit of the arch is only nine feet, which barely admits a waggon with a moderately high and wide load to pass.

If that portion of the arch immediately under the channel be lowered three feet, the road under it must also be lowered in order to retain a passage-way of the height above stated. This, together with the extension of the arches, will render it necessary to cut down, considerably, the inclined parts of the road leading to and from the culverts.

But even to obtain additional head-way, the road cannot judiciously be reduced to an extent that would in any way interfere with the foundations of the abutments, or leave them exposed to the action of frost, or direct influence of back-water from the river.

Although the height between the road and intrados of the arch might unavoidably have to be reduced to even less than it is at present, ordinary traffic would nevertheless be in a great measure accommodated, and, if necessary, arrangements could be made for

bulky articles to be taken from one side of the canal to the other on a ferry-scow provided for that purpose.

Attention having been drawn to the leading matters connected with the proposed enlargement, it may now be stated that an approximate estimate of the amount required to carry out the works would be as follows :—

Forming a new outlet for the canal, construction of two new locks, converting present locks into regulating weirs, formation and protection of banks, purchase of land, etc.....	$530,000
Raising, securing and protecting banks of levels between Locks Nos. 17 and 18, and between 18 and 19, lowering bottom and widening reach between Locks 19 and 20, constructing *three new locks*, building piers, abutments and a new swing bridge at Cornwall, lengthening out road culvert at Maple Grove, etc.....	800,000
Deepening and enlargement of summit level, constructing new guard and supply weir, docking at entrance, etc.....	830,000
	$2,160,000

APPENDIX No. 32.

CORNWALL CANAL.

SPECIFICATION for the Construction of Two Lift Locks and a Regulating Weir; and the formation of a New Lower Entrance, etc., SECTION No. ONE.

The new entrance channel is to be on the south side of the existing one, and in such a position that the respective centre lines of the two routes will be three hundred and fifty feet apart at the head of the present outlet lock, and four hundred and twenty feet apart opposite the head of what is known as Lock No. 17.

For a distance of fully two thousand feet at the lower end, the line will be straight, and then curve round gradually until the new south bank corresponds with that of the old canal, at a point nearly opposite the lower end of the landing wharf at the Town of Cornwall, about twenty five feet below, or to the eastward of which, the upper or western end of the section terminates.

The water level on the Cornwall reach, or that between Locks Nos. 17 and 18, is to be raised two feet, and the difference between that level and the River St. Lawrence will be overcome by means of two lift locks constructed for that purpose; a weir is to be built and other arrangements made for regulating the water; entrance piers are to be built, and such other works executed as herein described.

The new entrance lock will be placed so that its lower gate quoins shall be nearly opposite the upper quoins of the present outlet lock, and the lower quoins of the second lock will be opposite the head gates of Lock No. 17.

All permanent structures, such as the locks, weirs, entrance piers, side walls etc., are to be placed sufficiently low to afford a depth of water suited to 14 feet on the lock sills.

The centre line of the channel and the sites of the different structures will for the most part be as represented on the plan exhibited and marked out on the ground; but

the Department of Public Works reserves to itself the right of changing the whole or any part of the line as much as one hundred and fifty feet, either to the right or to the left of that shown, and of altering the position of any one or of all of the structures as much as three hundred feet either upwards or downwards of that indicated on the plan.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress without giving cause for any increase or diminution of the prices tendered for the respective items of work.

EXCAVATION.—The entrance is to be sunk to a depth of at least 6½ feet below the lower sill of the present outlet lock, and made 150 feet in width between the piers, which are to be of crib work, sunk on a foundation prepared for them, one foot lower than the general bottom.

All material excavated or dredged out in deepening or widening the entrance channel must be taken to such places within a distance of two miles as directed and be placed there in deep water, or, if required, the contractor must make arrangements to transport, hoist, and place the material removed so as to form and raise the banks at or within a distance of eight hundred feet of the entrance.

The foundation of the outlet lock will be about 350 feet long, 72 feet wide, and sunk 8 feet 9 inches below the top of the lower mitre sil of the present outlet lock; and the foundation of the second lock will be of like dimensions, sunk to within 4½ feet of the level of the same datum line.

In both cases, side slopes of one horizontal to one vertical will be allowed for the excavation of the pits; the contractor assuming the risk of removing, at his own cost, any slides that may occur, whether they result from leaving the sides steeper in the first instance or from any other cause whatsoever.

All the excavation required for sheet pile trenches, mud or sub sills, will be paid for at the same rate per cubic yard as the excavation for lock pits.

The reach or basin between the first and second locks will be excavated to within 6 feet 9 inches of the top of the mitre sill of the present outlet lock, and made of a mean width of 128½ feet, or a sectional area of 1,927½ square feet.

The reach above the second lock is to be made an uniform depth of 11 feet below present water line, or, to 13 feet in depth when the level has been raised two feet, as above stated.

About 700 feet in length of the present south bank of the canal is to be removed, or such other stretch of it as may be necessary to carry out the design herein contemplated.

From a point about 250 feet above the second lock downwards to the lower end of the latter, a raceway is to be cut and otherwise formed on the south side of the new line, and a regulating weir constructed nearly opposite the lower quoins of the lock. It is to be arranged to pass the ordinary surplus water over its breast, and have sluiceways placed at such a level as will admit of the reach above being fully drained. The water after it passes over or through the weir is to be continued at the same height as the reach between the locks, until it either enters the canal at that level or is discharged through a raceway into the river, or as may be found necessary.

All suitable material excavated from the lock pits, the reaches between and above the locks, the raceway, weir pits, bridge seats, etc., must be hauled and placed so as to form embankments in rear of the walls of the second lock, and for the forming of the new banks above that point to the upper end of the section, as well as raising and strengthening the north banks of the present canal, from the upper end of the section, to the lower end of Lock No. 17, and also both banks of the head-race to the mills and factories, from its inlet to the grist mill opposite the lower end of Lock No. 16.

The south bank above the second lock is to be at least 20 feet wide on top, and raised four feet over the surface water line, and the banks on the north must also be made at least 20 feet in width on top, and where those alongside of the canal and at the head-race to the mills must be strengthened, they, after having been made to the full height required, must be at least as wide on top as they are at present.

Where old banks have to be raised or strengthened, all sods, rubbish or objectionable matter must be cleared away and loose earth removed for such a depth and width as may be directed, and the new part of the bank formed of the best description of material that can be obtained from the excavation, which must be hauled on in carts or in waggons, and laid in layers in the manner subsequently described.

When the ground on which a bank is to be formed is below the water level of the canal, the surface must invariably be removed for such a depth as may be necessary, from the nature of the material and circumstances. In all such cases, the entire space to be occupied by the bank must be cleared of all sods, turf, muck, loose stones, all kinds of rubbish or objectionable matter; and all loose earth or such as would admit of water percolating through it, must be removed for such a depth as the officer in charge may consider necessary to enable a proper connection with the bottom to be formed.

The seat of all banks must be made nearly level, or have an inclination toward the side next the channel. This must be especially observed on the upper two-thirds of the section, or where a new bank will pass over the low and sloping ground adjoining the river, when the seat must be cut down so as to give a level bearing or to be formed into benches, each of which must of itself present a horizontal surface of sufficient width to admit of a suitable connection being made and so as to guard against any tendency to slide.

For preparing the seats of banks the material removed will be measured in the "solid" and the quantity paid for at the same rate as for earth excavation on section, which rate should be clearly understood to include the cost of handling of all kinds of material necessary to effect the object, and the entire removal of the same to such places, within the limits of the section, as may be directed.

The slopes of the banks on that part of the section above the second lock are for the most part to be one and three-quarters horizontal to one vertical on the inside lines, and on the outside lines the slopes are to be two horizontal to one vertical; but the outer slope on the high part of the bank or that next the river is to be such as will be most likely to guard against slides. The outer face of that part of the bank last mentioned is to be covered or protected by a wall of rip-rap boulder stone three and a half feet in thickness at bottom and two feet thick at top; the largest stones to be used for the bottom part of the bank.

All the stones from the surface water line of the river upwards must be hand laid, and when finished must form a moderately fair surface, corresponding to the general outline of the bank.

In all cases when making up a bank, care must be taken to place the best, most solid and water-tight earth in that part of it adjoining the canal, and to place all coarse materials, or such as are permeable to water, altogether beyond the limits of the same.

A continuous towing path is to be formed on the south side of the canal, and also on the north side from the lower end upward to the place where the new and old lines intersect each other. It is in both cases to be 20 feet wide on top and four feet over the water surface, increasing where the ascent is made to the second lock at the rate of one in fifteen.

In places where the natural surface of the ground is higher than the towing path line, the bank must be cut down to that height, and a ditch 2½ feet wide at bottom made at the foot of the slope, toward which the top of the track-way shall have a declivity of one foot transversely. The bottom of the ditch to have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

For the entire length of the section the bottom must be sunk uniformly to the depths before mentioned, and the sides, both in cutting and embankment, fairly trimmed to the angles above referred to, or to such others as are herein stated or may be subsequently determined.

When it becomes necessary to spoil material from the excavation or in preparing a seat for an embankment, the bank thus formed must be at least 50 feet back from the side line of the canal, in the position pointed out, and be carried up to the regular height with a top inclination outward from the channel of one in about sixteen, and with side slopes two to one.

When making up the banks of the canal, or embankments in rear of the locks or weirs, and at all such places where a bank is to be formed through or alongside of ground that is lower than the canal surface, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

PUDDLE BEDS,—when necessary to be made for the security of any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained at any place on the section, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock," the former to embrace all kinds of material found in forming the new entrance, cutting the canal, excavating lock and weir pits, removing present bank and deepening old channels, except absolutely connected "quarry rock," and detached stone or boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the canal and banks, forming embankments, making, raising and strengthening banks, grading towing paths and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications. But as the price per cubic yard, for each class of work, will be an average of the whole of that class, payments will only be made according to

the comparative value of the work, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been executed and completed the aggregate amount shall be the same as when the respective total quantities are calculated and extended at the prices stated in the contract.

LOCKS—to be 270 feet in length between the gate quoins, and 45 feet in width between the side walls at bottom. They are to be constructed of dressed stone masonry, laid throughout in hydraulic cement mortar, and placed on foundations prepared as hereinafter described.

The pits excavated for them will be in the positions and of the general dimensions previously stated, or they are to be of such other extent as may be necessary to admit the side and wing walls, and correspond with such lines as will be marked out on the ground by the officer in charge.

The foundation of the new entrance lock is to be $8\frac{3}{4}$ feet below the top of the lower mitre sill of the present outlet lock, and the bottom of the second lock is to be sunk to within $4\frac{1}{2}$ feet of the same datum line (lower mitre sill of outlet lock).

The bottom must invariably be trimmed smooth and fair throughout, at the levels above stated, which in both cases allow for a stratum of concrete twelve inches in depth to be laid under the foundation timbers, which are to be placed transversely and covered with three-inch pine plank, to form a protection for the bottom and a bearing surface for the walls.

The contractor, if directed, must sink that part of the bottom to be occupied by the side walls from three to six inches deeper, so that the stratum of concrete at these places may be from 15 to 18 inches in depth.

If solid and suitable rock in thick layers is found at the proper level, at the place where a lock is to be built, the walls will be commenced upon it without an artificial foundation; but if the rock be unsound, the fissures in it numerous, the strata thin or irregular, a floor of pine timber covered with three-inch pine plank will be laid, as provided for a foundation on earth or clay.

The material excavated from the lock pits, when of a suitable kind, must be hauled and placed so as to form embankment at or near the upper end of the section at the places and in the manner previously described.

FOUNDATION TIMBERS—to be of pine, 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up the distance, one of which must, however, extend from the rear line of one wall, across the chamber, to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill and at the lower end of the lock, and must rest uniformly for their entire length on the bottom, and on sills placed under the walls. The spaces between them must, immediatly after they are properly laid, be well filled with the best description of concrete, and their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if directed.

SUB SILLS.—Two ranges of sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches wide and 4 inches

thick, arranged and laid on a bed of thin mortar and at a height that their tops shall be on the same level as the surface of the adjoining concrete. A space of 4 inches is to be left between the ends of the respective pieces, and they are not to pass through the sheet piles, but must be left 6 inches short on each side; all these spaces are afterwards to be well filled with fine concrete in the manner required.

MITRE SILL PLATFORM—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts (1½ inches in diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

Each platform, after it has been put together, must be raised a sufficient height to admit of spreading a bed of thin mortar over the place it is to occupy. When this has been done the platform is to be lowered and well beaten down to its proper bed, or such other course may be adopted for that purpose as may be approved.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

TRENCHES, ETC.—Five or more trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed 2½ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be filled with concrete to the height of the adjoining ground.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation, and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet, and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails 9 inches long and 1½ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid, the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenoned and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches, checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep is to be cut in the lower edge of the mitre sills to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead, and when about to be placed in their berths, a strip of canvas well saturated in boiling tar is to be placed in the check formed in the platform into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½) diameter, have upset heads, and be well ragged at the point.

If the foundation is rock, the mitre sill platforms will be made as above described, laid in a full bed of mortar, and secured to the rock with fox and key-bolts and at the outer edge on both sides will be connected with a stop-water timber let into the rock.

Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide and of sufficient height to form a close joint with the outer timber of the platform.

Before a stop-water is placed in its berth a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check, the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts 1¼ inches in diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than that occupied by the platform, there are to be timbers 12 inches square, laid 6 inches apart, also for a distance of 12 feet below the lower side of the platform to the upper end of the wing walls at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts 1¼ inches diameter passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete and their upper sides dubbed to a fair surface for the planking.

If found necessary to lay timbers in the chamber of the lock on a rock foundation, they are to be placed 12 inches apart and the spaces between them filled with concrete.

MASONRY.—The locks are to be 13¼ feet lift and the side walls carried up to 3 feet over the surface water level of the upper reach, or to the height of 30 feet 4 inches over the top of the first course of plank.

The chamber and recess walls are to be 10½ feet wide at the bottom, with counterforts in rear 6 feet long in line of wall and with 3 feet projection, placed not more than 12 feet apart.

The recesses for the gates are to be made 2 feet 8 inches deep at top, and the walls are to be 10½ feet thick at the bottom.

The face of the chamber and wings is, throughout, to have a batter of *one* in *twenty-four;* but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be of approved sound and durable stone, free from drys, seams or other defects; those forming the face work must be of the best class of grey limestone, or at least fully equal in every respect to the very best samples of the stones used for face work in the present locks on the Cornwall Canal.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stone of equal height.

From the lower end of the lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths of an inch.

The chamber walls between the points above mentioned are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths of an inch.

CUT STONES—to be neatly dressed and boucharded; made square, bevelled, or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of the beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than two and three feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged, as nearly as possible, mid-way between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers, in the alternate courses, must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{2}$ times their height; and in all cases the tail of a header must have a width of two-thirds ($\frac{2}{3}$) the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least 5 feet face and 6 feet depth of bed; the latter 6 feet face and 5 feet bed in the top courses, increasing in dimensions downward at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 5 by 6 feet, laid alternately out-bond and in-bond, bevelled as shown on plan; the header to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain wells in the position, indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag-chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face of the walls of the recess, and are to be properly bonded over and with each other at the angles.

CHECKS.—For the reception of stop-water timbers, two checks are to be formed in the face of each of the wings at both ends of the locks; they are to be arranged as shown on the plan, be 2 feet apart, 12 inches wide, and 6 inches deep at the top, and made plumb in the rear.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed, in alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches in length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire

depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed three-eighths of an inch.

BACKING—to be of an approved class of large well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face-work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin wedged-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth of the area of the stone, it must be still further reduced. After this has been done, the stone laid, and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

Stones with dry or clay seams in them, or in any way of an inferior kind, or stones not of the size or shape to make substantial work, will not be allowed in any of the walls, nor will they be permitted to be brought on to the section.

COPING STONES—of the chamber, recesses and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 18 inches in height of course and not less than 4 feet long in line of wall.

Great care must be taken in the selection of stone for this purpose, as none but those of the soundest and best kind, free from vertical and horizontal seams, drys, sand holes and other defects, will be allowed in the work, no matter when or at what stage of the preparation of the stones the defects are discovered.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

The descent from the coping of the locks to that of the pier, in the one case, and the wall or bank in the other, is to be made on both sides of each lock by means of a range of steps 4 feet in width, cut out of the solid; the rise of the steps not to exceed 10 inches, and the treads to have an uniform width of 12 inches. They are to be arranged, placed and secured in the manner directed as the works proceed.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be of coursed masonry, 7 feet wide at bottom, plumb in the rear, and on the lower side battered to a width of 5 feet at the top, and then covered with large, flat-bedded, scabbled and well-jointed coping stones.

MORTAR.—The whole masonry of the locks and other structures to be described must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and, until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the directions and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half ($1\frac{1}{2}$) of clean, sharp sand to one of cement and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

CONCRETE,—where used, must consist of an approved quality of stone broken to cubes of $1\frac{1}{4}$ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand in such proportions as may be required.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED,—in rear of the lock walls, to be three feet in width, carried the entire height; it must be made of the best description of material that can be obtained on the section, laid on in layers not exceding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

RUBBLE WALLS,—forming the extension of the wings at the head and foot of the locks, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over and with each other and laid in cement mortar for such a distance below the lock as may be directed.

These walls are to be built to such lines as will form a suitable connection between the locks and retaining walls, or the slope walls, as the case may be; and the face of the stones must be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

LOWER ENTRANCE.—As previously stated, the approach to the canal is to be sunk to a depth of 6½ feet below mitre sill of the present outlet lock, and made of a clear width of 150 feet.

The sides are to be of crib work, for which the seats are to be sunk one foot lower, or to the depth of 7½ feet below the mitre sill of the old lock, and the whole carried up to within six inches of the ordinary low-water line. On the north side of the channel the pier will be about 300 feet in length and 18 feet in width, and the one on the south or river side will be 250 feet long and 25 feet wide; at the inner end, each of them will be connected with the adjoining wings of the lock by means of a wall of a heavy class of masonry. The superstructure on the piers may be either of masonry or timber work, or partly of both, as may be determined on the probable action of the ice jam in that vicinity being more fully ascertained.

CRIB WORK—to be of the full width above stated, for the respective places, and in lengths of at least 30 feet. The side and end timbers must be at least 11 inches square, and invariably be straight, sound and full on the edges for their entire length.

FRAMING.—The outer or face timbers on both sides of the cribs must be framed and laid so that the horizontal joints between the different courses shall be close for at least two-thirds of their length, and at no place exceed one-half (½) an inch. At the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and five-eighths (⅝) of an inch in diameter is to be driven through the dovetail.

CROSS TIES—to be of flattened timber, 10 inches thick, of a sufficient size to square 10 x 11 inches at both ends, and of the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above. Their ends are to be dovetailed 4 inches into the timbers under and over them, and have a square shoulder of one inch on both the upper and lower sides. The dovetail to splay 1½ inches on each side, so as to stand 8 inches at the neck and 11 inches at the outer end.

A rag-bolt 2 feet long, seven-eighths (⅞) of an inch diameter, is to be driven through the head of each tie, passing through the course on which it rests and into the course below.

LONGITUDINAL TIES.—In all the cribs of the south pier, longitudinal ties 10 inches thick are to be framed into and dovetailed between the alternate tiers of end timbers, and be secured by bolts of similar dimensions and in like manner as described for the transverse ties. They are to be notched into the

cross ties and fastened at the crossings by means of white oak treenails 2 inches diameter and 16 inches long.

In the cribs forming the lower termination of the south pier, there are to be longitudinal ties in every course, placed alternately 7 feet and 18 feet from the outer sides.

The cribs are to be further secured by vertical ranges of binders placed inside, and extending from the lowest side timber up to the water line. There are to be three ranges on a side, *i. e.*, one at or near each angle, and another in the centre, making in all six vertical ranges in a crib; to afford a fair bearing for which, the side timbers must be "spotted."

The binders are to be of plank, 4 inches thick and 10 inches wide, fastened from the inside by 10-inch spikes, five-eighths ($\frac{5}{8}$) of an inch diameter, two driven through each plank into the lowest side pieces, or that on which the ballast floor rests, and one at every crossing of a side timber from the floor upwards. They may be put on in lengths of from 8 to 10 feet, or more, but they must be arranged so that the upper length shall in all cases reach down at least 18 inches lower than the top of the plank of the same range; and care must be taken to have their top and bottom ends well fastened.

Ballast Floors—to be of flattened timbers, 10 inches in thickness, and of the full length to pass through the respective cribs. They are to be laid transversely from eighteen to twenty four inches apart, or such other less or greater distance apart as circumstances may require, and rest on either the first or second course of side timbers as may be directed, and to which each piece, at both ends, is to be fastened by a rag-bolt three-fourths ($\frac{3}{4}$) of an inch diameter, and 18 inches long. When considered necessary to place the ballast floor on the second floor of side timbers, there must be two or more longitudinal pieces dovetailed into and secured to the end pieces at the proper height to form bearingsfor the floor.

The cribs, from the bottom upwards, to low-water line, may be formed either of pine, oak, elm, ash or tamarac timber; but whatever kind is used, it must be of the full dimensions, straight and of good quality, free from shakes, sap-wood, unsound knots, or other defects.

Before a crib is put together, the contractor must in all cases take correct close soundings over the place it is to occupy when sunk, and any boulder stone or abrupt irregularities found within range of the pier must be removed, and if found that this cannot be done, the bottom of the crib must be adapted to them, so that when placed in its berth, the sides and ends shall be plumb, and the whole form a line corresponding to that marked out by the officer in charge.

Immediately after a crib has been moored in the right position, the contractor must lay a platform of plank over it of sufficient size and strength to carry stone enough to sink it, and when sunk and ascertained to be in the proper line and place, the crib is to be filled with an approved class of moderate-sized stone, packed as closely as possible.

At the lower end of the south pier, a sloping ice-breaker is to be formed, if directed, the bottom width of which will be 50 feet. The additional width to be added to the south side of the pier; and the top side of the lower end, as well as that of the south side are both to be made to slope upwards at about the rate of three horizontal to one vertical, from a line as nearly as possible four feet below ordinary water level. Both inclines to be made crowning in the centre, and be covered longitudinally with oak timber at least 13 inches in depth.

The covering to be laid close throughout if so directed, otherwise it way be laid to open joints with blocks at the bearings, fastened horizontally at the time when work is in progress. In either case the timbers must be well fastened to the cross ties and bearing timbers under them, with screw and rag-bolts alternately, and be further secured by such straps and bands of wrought iron as may be required. The whole to be trimmed to a fair surface on top, and everything done that may be necessary to guard against any direct resistance to the action of ice brought down by the current, or resulting from other causes.

SUPERSTRUCTURE.—With the exception of a stretch of about 30 feet in length of that part of the south pier adjoining the ice-breaker, the superstructure of both piers, if circumstances permit, will consist of a wall of masonry laid in cement mortar, started on the tops of the cribs at about 5 inches back from their front edge. Before it is commenced, however, the ballast for six feet in width along the front side of the different cribs must be well packed and beaten down, at a height to admit of a continuous tier of large flat-bedded stones being laid at the same height as the front timbers of the cribs, and whatever may be requisite to form as good a bearing for the wall as can be done under the circumstances.

The wall is to be five feet eight inches wide at bottom, carried up plumb in the rear and to a batter of five inches to the foot rise, on the front side. The face to be of stones, laid upon their natural beds in regular courses, which may vary from 8 to 16 inches in height, the highest being at the bottom, and a course once commenced must be continued at the same height throughout, or for such distance as may be approved. All the face stones to have an area of bed of at least 6 square feet, and generally be laid with their greatest length or depth inwards; their faces are to be hammered straight and square, so that the batter can be formed by off-sets on the different courses. The coping course to be at least 10 inches in height, 3 feet in width, and generally not less than 3 feet length of face, picked or scabbled so as to lay to close joints, and present a fair, uniform surface on top. The backing to be of large well-shaped stones, and they, as well as the face work, must be laid in a satisfactory manner, in full beds of hydraulic cement mortar, and so as to break joints properly over and with each other.

The joints in the different courses must be grouted up as the work progresses, and everything done that may be necessary to make the wall of the best description of undressed, coursed masonry.

The walls above described are to be connected with and bonded into the rubble walls carried up in extention of the lower wings of the lock. A space in rear of the north pier is to be filled in from the excavation, and carried to such a height as may be required, care being taken to have a width of at least 15 inches immediately alongside of the wall filled in with stone. On the south side of the entrance the space colored pink is to be filled in and the outside of the bank protected with a rip-rap wall of stone of such a thickness as may be directed.

REGULATING WEIR AND RACEWAY—to be constructed on south side of the new line in the position indicated on the general plan. The weir will be opposite the lower gates of the second lock; it will have a spill-way exclusive of the centre pier of 47½ feet, and its foundation will be laid at the depth of 6 feet below the surface water line of the lower reach. The head race will leave the canal at a point about 600 feet above the weir; it will have a mean width of 32 feet and be sunk six inches lower than the bottom of the Cornwall reach.

The lower race will have a bottom of timber and plank laid at a like height as the floor of the weir, except that part opposite the lower weir and discharge race where the

bottom, if required, will be 9 feet or more below the surface water line of the reach between the locks.

EXCAVATION.—The pit for the weir, and cuts for the water-way leading to and from it, are all to be made of suitable dimensions to admit the respective side walls, and the contractor, when proceeding with the works, must invariably be guided by the levels given for the bottom of cuttings, height and grade of banks and lines marked out by the officer in charge.

An allowance of one horizontal to one vertical will be made in the excavation for a slope in rear of the side walls of weir, and an allowance of one-half horizontal to one vertical will be made in the excavation for a slope in rear of the side walls in case the latter are made vertical. On embankments the side slopes are to be made from one and half to two horizontal to one vertical, or to such other angle as the position of the work or circumstances may require.

All suitable material excavated from the weir pit, sheet pile and puddle trenches, the race-way, etc., must be hauled, placed and disposed of in embankment at one or other of the places previously mentioned, either on the north or south side of the canal, as may be directed.

All the masonry and other works connected with the present weir on the section must be removed at the time and in the manner required, and the stones considered by the officer in charge suitable for use in the new weir may be placed where they can most advantageously be got at for that purpose. The balance of them may be used for side walls or for rip-rap, or for such other purposes as circumstances may warrant.

Contractors will please bear in mind that in addition to what is called the regulation weir, arrangements are to be made to supply the level between the first and second locks over or through a breast wall built for that purpose in line of the south bank of the canal. This breast wall, pier and bridge abutments connected with it, as well as their foundations, will be considered and described as the "lower weir," and the upper one will be called "the weir."

FOUNDATIONS—of weirs and of the lower raceway are to be formed of pine timber 12 inches square, laid transversely from 10 to 12 inches apart, except for the lower weir, where the timbers are to be laid longitudinally.

The timbers for the lower race must be of the full length to extend across the race and from rear to rear of the side walls; those for the weir may occasionally be in two lengths, provided the centre portion of the end of one piece enters horizontally 4 inches into that of the other, and underneath there be a binding piece 10 feet in length, secured by two wrought iron screw-bolts $1\frac{1}{2}$ inch in diameter.

The floor timbers of the weir are to be laid so as to rest on mud sills placed within the line of the side walls, and on the bottom, throughout their entire length; sub sills, if so directed, are also to be laid under the bottom timbers of the lower raceway at about the front line of the side walls.

In case sub sills are put in, they are to be placed and arranged in like manner as those described for the foundation of the locks.

The spaces between the timbers, as well as alongside of the sub sills, are to be filled with the best description of properly-made puddle, well beaten down; otherwise concrete,

either in part or as a whole, may be used if considered necessary by the engineer in charge.

As above stated, the foundation timbers for the lower weir are to be laid longitudinally and must be of a length to pass from rear to rear of the side walls, which form the abutments of the towing path bridge, and a continuation of the retaining walls at the lower end of the raceway.

At this place a course of four-inch sheet piles, six feet in length, is to extend across the water-way; a like course of sheet-piles is to be put in above the breast wall; another on the channel side of the apron, connected with the lower weir; and a fourth at the breast across the discharge race, as represented on the plan.

In the foundation of the weir there are to be four ranges of sheet piles, *i.e.*, one at the upper end, another at the lower end, one above and one below the breast wall; they are generally to be of pine plank, 4 inches thick, 6 feet long, jointed, prepared and fastened, and the trenches cut for their reception made of the size, and subsequently well filled with puddle, and the whole work connected with them executed in the manner described for those in the lock foundation.

The range of piles in line with the upper side of the breast wall of the weir must extend beyond the rear of the side walls and into the solid bank on the north side, and on the south side to the back of the masonry of the new lock, and in both cases to be carried up to water line of the upper reach.

FLOORING—to consist of two courses of approved pine plank. The first, 3 inches in thickness, is to extend over the whole area of the foundation of the weir, raceway apron; and the second course, 2 inches thick, is to be laid between the side walls for the entire space below the breast wall of the weir. They are to be well jointed, and in every respect be laid to break joints, and be fastened, the lower course with white oak treenails, and the upper course with pressed spikes, and in every other respect the work connected with them must be done as described for the floors of the locks.

MASONRY.—The walls are to be built in the positions, and generally be of the respective dimensions marked or represented on the general plan; they must consist throughout of an approved class of sound and durable stones, free from seams and other defects, laid in full mortar on their natural beds.

It is to be clearly and distinctly understood that it is only those parts of the work between the ranges of sheet piles at what is called the upper and lower ends of the weir, embracing, of course, the breast wall, wing walls and centre pier; also the breast wall, centre pier and abutments connected with the lower weir, and the breast wall of the discharge race, which will be measured, estimated and paid for as weir masonry.

WING WALLS—to be 8½ feet thick at bottom, face to be "rock work" with a batter of one in twelve, the stones to be at least 2 feet long in line of wall; 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course; the whole to be dressed and laid so that the beds and end joints shall not exceed three-eighths (⅜) of an inch. The backs of the walls are to be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping, which is to be 3 feet in width.

BREAST WALL—to be 11 feet in width at bottom, 4 feet at top, and 17 feet high, built of stones 2 and 3 feet depth of bed in the alternate courses

with headers in each course 4½ feet deep, and not more than 9 feet apart; all of them must be dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side of the wall to be plumb, and the faces of stones dressed fair and smooth to receive the framework of the sluices, and the lower side is to be rock faced work laid to a batter of about 5 inches to the foot rise.

There are to be six sluice-ways through this wall, each 4 feet wide and 4 feet high, the top, bottom and sides of which are to be dressed smooth. The sills under them and lintels over them to be from 14 to 15 inches in height, and 6 feet long, each dressed so as to lay to close and full joints, and present a fair surface through the respective openings.

All the piers between the sluice-ways, except the supporting pier in the centre, must be made of stones, dressed to the proper width (2 feet), bonded over and on to each other at least 1 foot.

CENTRE PIER—to be 5 feet 6 inches in width at the floor, carried up to such a batter on both sides that the top shall be 3½ feet in width. This pier, coping excepted, may be made of two widths of stone, provided there are double headers in each course not more than 8 feet apart.

The arrises of all the face stones on both the upper and lower sides of the breast wall, the centre or supporting pier, the sills, lintels and piers of the sluice-ways must all be kept good, and the whole dressed and laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

Near the upper end of the weir, checks are to be cut in the face of each of the wings, and on both sides of the centre pier for the full height of the walls, for the reception of stop-logs. Below these checks a cross-wall, 2 feet 10 inches wide and 2½ feet high, is to be built of blocks of stone the full width, properly bedded and bonded and well secured with dowels and vertical bolts, in such a manner as may be required.

COPING.—The breast wall coping must be at least 16 inches high and 4 feet wide on top, increasing in width downward to the batter of the wall. The lower bed and joints must be kept full throughout, and the top dressed fair, so as to have a declivity of 1 inch toward the up-stream side.

It is to be in lengths of not less than 3½ feet, and be connected with dowels at the joints, and secured with bolts to the course underneath.

The coping of the wing walls and centre pier to be at least 12 inches in thickness, the former three feet and the latter three and a half feet in width, all of which must have full beds and joints, and be neatly boucharded on top.

In addition to the range of sheet piles to be placed in line of the breast wall, a counterfort of masonry 4 feet thick and 6 feet in length is to be carried up in connection with each of the wing walls to the height of the water level of the upper reach.

BACKING—to be of a like class of stone and workmanship as described for that of the lock-walls.

The whole of the weir masonry must also be laid in the best hydraulic cement mortar, mixed and prepared as stated for other portions of the works.

A puddle bed 3 feet in width is to carried up in rear of the side or wing walls to the full height of the water level of the upper reach. The material used for this purpose, as well as for the puddle between the foundation timbers, and for the sheet pile trenches, must be of the best and most suitable kind that can be obtained on the section or in the vicinity of the work.

SLUICE GATES—to be built of the best quality of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to 3½ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths (⅞) of an inch in diameter, passing through the gate; and to have straps of wrought iron 3 inches wide and three-eighths (⅜) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush, and fastened at distances not more than 6 inches apart, with rivets ½ an inch in diameter countersunk into the straps. The top plates are to be 2¾ inches deep, and those at the bottom 6½ inches deep, each to have a flange from the centre outwards on opposite sides.

The gates are to revolve on the centre, on pivots working into the bottom plates of the gates, and on the top of each a disc of steel or hard brass is to be placed, and have a brass collar and lining. The pivots are to be 3½ inches diameter, connected with plates 9 inches square and 2 inches thick, let into the sills of the sluice-way, and secured to them by fox-bolts.

The gates are to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key-bolts to the piers and lintels of the sluice-way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed.

The turning rods are to be of wrought iron, 3 inches in diameter, of sufficient length to pass through the gates and stand six inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates, and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected with racks on the platform, made so as to secure the gate in the position required.

The bridge or platform placed over the weir for the convenience of working and securing the sluice gates is to be of pine timber, in pieces not less than 12 inches deep, and of such width as may be required. The lower range of timber, or that adjoining the breast wall, is to be made up of two pieces, each 15 inches in depth, with an air space and proper bearings between them. They are to be secured in the masonry, and painted with three coats of white lead. The breast wall in the discharge race, the abutments, centre pier and breast wall of the lower weir are to be of a like class of work respectively, to that previously described; but in the latter (the breast wall of the lower weir) the water-ways will be of less dimensions, less in number and placed higher than in the regulating weir.

RACEWAY MASONRY.—Above and below the weir the sides of the raceway are to be formed of "random-coursed masonry," that is to say, that both beds of the face stones must be level, but continuous courses will not be required.

Above the weir the side walls are to be 17½ feet high, and 6 feet wide at the bottom, the face sides of which are to have a batter of 1½ inches to the foot rise, and the back to be carried up plumb to within 5 feet from the top, thence batter to the rear line of the coping. In rear of these walls, and in connection with them, counterforts 4 feet

long and 3 feet deep are to be carried up, 16 feet apart, to within five feet of the top of the bank.

Below the weir the side walls of the raceway will be of a like class of masonry as that described for those above it, but of less thickness; and about 60 feet below the breast wall of the weir, and for a height of 7 feet over the floor, the side walls are to be recessed, or stand back 2 inches to receive a lining of plank to protect the walls from the direct action of the water discharged over or through the weir.

The face of the end wall of the raceway, or east wall between the lower weir and discharge race, is to be recessed and lined in like manner.

This lining is to be of well-jointed two-inch pine plank, fastened to the flooring, and at other places to three bond timbers 4 × 5 inches, built into the face of the walls as the works proceed. The walls above referred to are, as already stated, to be "random-coursed work," built of large-sized, sound, flat and well-shaped stones, properly bonded over and with each other. The stones forming the face of the walls must be picked or scabbled to lines suited to the position they are to occupy in the work; and in every 15 inches in height of the walls there must be headers of at least 3 feet in depth of bed, placed not more than 7 feet apart.

The coping stones must be of full dimensions, 2½ feet in width on top, increasing downward to the batter of the wall; they must be at least 10 inches in height and 2½ feet in length, and be neatly picked or scabbled on the face and top; the lower bed and ends must also be kept full so as to make close joints throughout.

The bridge abutments at the upper ends of the raceway are to be 8 feet thick at bottom, the face of which will have a batter similar to that of the adjoining walls, and the back to be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping, which is to be 3 feet in width and at least 12 inches in height.

The centre pier to be 5 feet 11 inches wide at bottom, and be carried up to a batter of one in twelve on both sides, so that the coping will be 3 feet in width on the top. All the face work of this bridge is to be of "rock work" of a like class as that described for the masonry of the wing walls and centre pier of the weir.

All the masonry connected with the weir, bridge abutments and raceway must be laid in approved hydraulic cement mortar, and the walls be properly grouted—the mortar, etc., to be prepared as described for the lock in a preceding part of this specification.

Contractors are also expected to state a price in the tender for which they would be willing to protect the sides of the raceway, from the towing path bridge, downwards, to the regulating weir, in manner following, viz.:

2.—Making the inclination of the bank one-half horizontal to one vertical, and facing it with pitched stone 3 feet in depth at bottom, 2½ feet at the water line; stone to be laid dry on a foot in depth of quarry refuse or gravel and at right angles to the face, in regular courses 6 inches or more in thickness—one-third of the superficial area to be of stone the full depth of bed above stated, the other two-thirds may be made up of two stones.

The rear part of the first or lowest course to be let into the bottom, and on top the coping is to be laid horizontal, 2½ feet in width and 9 inches thick; otherwise the top stones are to form a rounded edge if so directed.

The stones must in all cases bond properly over and with each other, and the whole be executed in a satisfactory and workmanlike manner.

It is to be distinctly understood that the tender for either the vertical wall or the inclined protection wall may be accepted as a whole or in part without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

PRISM OF CANAL.—The inside faces of the banks or sides of channel between the two locks embraced in this section are to be protected, in some one, or any two, or it may be partly in each of three following ways, as may be subsequently determined :—

1.—By a covering of pitched stone of an approved class, laid at right angles to the face, on or about twelve inches in depth of quarry waste or gravel. The pitched stone to be in regular courses, varying from *four* to *eight* inches in thickness, and from a depth of twenty two inches at the bottom part, to a depth of sixteen inches at the top-water line, laid throughout in coarse sand or fine gravel, and have the joints in the respective ranges properly broken over and with each other.

Where the bottom is clay or other material of that kind, the first tier of stones is to be let in their full depth, in the position above mentioned, and laid so as to form a toe support to the wall. The whole of the stones to be well rammed and beaten down to a fair uniform surface.

2. Making the inclination of the bank one-half horizontal to one vertical and facing it with pitched stone 3 feet in depth at botton, 2½ at the water line ; stone to be laid on a foot in depth of quarry refuse or gravel and at right angles to the face, in regular courses 6 inches or more in thickness—one-third of the superficial area to be of stone the full depth of bed above stated, the other two-thirds may be made up of two stones.

The rear part of first or lowest course to be let into the bottom and on top the coping is to be laid horizontal, 2½ feet in width and 9 inches thick ; otherwise the top stones are to form a rounded edge if so directed.

The stones must in all cases bond properly over and with each other, and the whole be executed in a satisfactory and workmanlike manner.

3.—Constructing a wall 2½ feet wide on top with a batter of two inches or more to the foot on the front side, and on the rear to increase 3 inches to the foot for the first five feet from the top, thence downward they are to be plumb.

The wall must be built of an approved class of sound and durable, flat and well-shaped stones, not less than 6 inches thick, 2 feet or more in length and have 3 feet area of bed at least, laid so as to form proper bond over and with each other in both front and rear ; the faces of the stones must be hammered or scabbled to a line corresponding to the position they are to occupy in the work.

Headers not more than 7 feet apart and at least 3 feet depth of bed are to be placed in each course.

The coping stones must be 2½ feet wide, fully 9 inches thick and not less than 3 feet long.

In rear of the walls a space of about 12 inches in width is to be made up with small stones or quarry waste, well rammed.

The foundation for the walls in either case to be sunk to 15½ feet below the surface water line of the canal.

Contractors are requested to submit a price for each of these three different kinds of protection for the banks, subject to the distinct understanding that they provide, at their own cost, all the necessary materials, and that the work to be done may consist of all *three* kinds, or it may be of *two* of them, or wholly of *one* kind without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

From the south end of the tunnel, under the canal, or from such other point south of the road or street on the north side of it as may be found necessary, a sewer about 2½ feet wide and three feet high is to be built through under the new line at 10 feet under the canal bottom, or at such other depth as may be required to give efficient drainage. The bottom of the sewer to be of large flat-bedded stones, laid close throughout and not less than 9 inches in thickness and of such length as will give both the side walls a bearing on them of at least six inches.

The side walls are to be 3 feet thick, built of large-sized flat-bedded stones, properly bonded. The covering must be at least 12 inches thick, laid to close joints, and have in all cases a bearing of not less than 9 inches on the side walls, which at top are to be carried up obliquely to the upper side of the covering and the whole well flushed with mortar.

The excavation for the sewer pit to be paid for at the same rate as for the foundations of the locks. All the spaces between the walls of the sewer and the bank to be filled with puddled material, and great care taken in filling in the space over the sewer to have the material well pounded and rammed, and every precaution adopted in the way of forming puddle walls, etc., that may be required to render the whole secure.

Contractors are requested to state a price per cubic yard for which they would be willing to undertake the removal of all the masonry and foundation work of the tunnel under the canal.

The whole space from rear to rear of the abutments or side walls, and from the foundation to the crown of the arch to be measured, computed and paid for as solid, and the wing walls at both ends beyond the head of the arch to be measured correctly in each case, and payment made for the actual quantity of masonry removed.

All the stones taken out of the old works that the officer in charge may consider fit for backing or for other use in the new works, are to be piled or placed for that purpose on the most convenient unoccupied ground in the vicinity. The refuse material, or such as have been decided as unsuitable for use in the walls are to be hauled to the south side of the new line of canal and deposited there, or be otherwise disposed in such manner as the Department of Public Works may approve.

The earth excavation for that part of the banks over the masonry will be paid for at the same rate as other parts of the section excavation, and the preparation of a seat for the bank at either or both ends of the tunnel site will be dealt with as for the preparation of the seat of any other bank. The making up of the bank at the north end of the tunnel site and forming a connection between it and the old banks on either side

will be looked upon as a service the contractor agrees to perform in disposing of the material removed from the prisms of the canal, and which will be paid for in excavation.

To effect this object, as well as for raising and strengthening the banks on the north side of the canal and head-race to the mills, the contractor must, at his own cost and expense, provide the necessary means of crossing the canal.

The raising of the water level on the Cornwall reach renders it necessary to raise the walls of the head gates to the mills, also the walls at and above the gates of Lock No. 17. Both these works will be paid for at the same rate per cubic yard for the materials supplied and quantity of work done for the respective purposes as paid for new works of the same kind, *i.e.*, the price of supply weir masonry will be paid for the addition to the head gates, and the price of lock masonry for raising the walls at the head of Lock No. 17.

It may be stated for the information of parties intending to tender for the execution of the works, that the greater part of the material to be excavated on the section lock pits, etc., is of a hard nature, consisting of indurated clay, gravel and boulder stones, firmly cemented together. It should further be borne in mind that the bulk of the excavation has to be hauled and placed so as to make up the banks at the upper end of the section, the cost and expense of all of which must be embraced in the price tendered for excavation, as the work will be measured and estimated in excavation only.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty ; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time, and in the order required by the Department of Public Works ; all of which must be executed agreeably to the plan contemplated in this specification and the directions of the officers in immediate charge, although all that may be required to complete the design may not have been particularly described.

The bulk sum tendered for unwatering the works must embrace the cost of constructing all coffer dams required to keep out the water of the River St. Lawrence, as well as that of the present canal, and to guard against leakage, springs or surface drainage, together with the expense of pumping, bailing, removing ice and snow, and every contingency directly or indirectly connected with unwatering the lock and weir pits, or any other portions of the works during the progress of the operations, and up to the full completion of the whole undertaking ; and the satisfactory removal of all coffer-dams and other temporary constructions.

Gates for the locks will be built under a separate contract.

Detailed Plans.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction ; but detailed working drawings, arranged, modified and adapted to the lock and weir foun-

dations, and for all such other parts of the structures as may be required will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads or for the placing or preparing of materials, beyond the land that may be acquired for canal purposes by the Department of Public Works. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the works as contemplated in this specification.

All materials must be of the best class of their respective kinds; and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, and the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the work embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty-fifth day of April, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 25th July, 1876.

APPENDIX No. 33.

Cornwall, 30th November, 1879.

SIR,

In accordance with your instructions of the 8th inst., I beg to submit the following report upon the enlargement of the Cornwall Canal, wherein I have endeavored to supply information as to the general character of the works under contract, the progress made thereon from their inception in 1876, their present condition, and the work which remains to be done.

The work now to be described, and at present in my charge, is known as Section No. 1, Cornwall Canal Enlargement.

The contractors are Messrs. Gordon, Woodward and Chamberlin, of Sherbrooke, Province of Quebec.

The contract was signed August 23rd, 1876, and the date named therein for its completion, the 25th April, 1879.

Work was begun on the section 2nd September, 1876 ; my connection with the work dates from the 12th May, 1877.

Section No. 1 of the enlargement commences in the bay below Potash Point, in the Town of Cornwall, abreast of the present Entrance Lock No. 15, and at a distance of a little over 300 feet south therefrom.

Thence it extends westward across the Point, in a direction nearly parallel with the old canal, to the east end of the wharf at the foot of Pitt Street, a distance of about 3,800 feet. The undermentioned works are embraced in the contract for Section 1 and will be referred to in the order in which they occur, ascending from the River St. Lawrence.

1.—The Lower Entrance.

2.—Lock No. 1. 3.—The Basin. 4.—Lock No. 2. These structures overcome difference in level between the St. Lawrence and Cornwall Reach, at present effected by means of three Locks, Nos. 15, 16 and 17.

5.—The regulating weir, including upper and lower raceways, the lower weir, and discharge race.

6.—The Sewer.

7.—The towing path and canal proper.

8.—Various works connected with the present canal, including raising walls of Lock No. 17, supply weir, etc.; the banks of canal and head-race to mills, opposite lower entrance; the removal of tunnel and waste weir, and of a portion of the south bank or towing path. The scheme for enlarging the canal contemplates raising the water two feet in the Cornwall Reach between Locks Nos. 17 and 18, and also lowering the bottom two feet.

The levels of Lock No. 2, the regulating weir and canal proper have been arranged in accordance therewith.

The datum for construction is an assumed line ten feet below the surface of the lower mitre sill of the present entrance lock (No. 15), and the levels of all structures and grade lines in excavation and embankment, have been established with a view to afford a depth of water of at least fourteen feet on the mitre sill of the enlarged entrance lock (No. 1) during the lowest known stage of the River St. Lawrence. The lowest water (8′.8″) on sill of Lock No. 15 as recorded since 1849, a period of 30 years, occurred in November, 1872, and was equivalent to the level of 18′.66 above datum.

General Description of the Works.

The Lower Entrance.—As previously stated, the new entrance channel is fully 300 feet south of the present entrance.

From the tail bay of Lock No. 1 to deep water is about 350 feet. This distance for a varying width of 150 to 170 feet has been reduced by dredging to the level of 3.′50+, affording a depth of 15 feet at extreme low water.

On either side of the channel, a pier of close crib-work connected with the extension of lock wings has been formed, upon which a superstructure of coursed masonry in cement, founded below ordinary low water, is to rest and serve as a retaining wall for the embankment in rear. The seats of the piers are dredged to the level of 2′.50+, when a hard uniform bottom was obtained. Their upper surface for a width of 6 feet back from the face has been dubbed to the level of 19′.42+, and the stone ballast packed and blinded with quarry waste, to receive the superstructure.

The level of coping of superstructure and the adjoining embankment is 25′.42+.

The dimensions of the cribs composing north pier are 30′ + 18′ + 18′; and those in the south pier and ice-breaker are 32′ + 25′ + 19′.

The north pier extends about 350 feet east from Lock No. 1, and from the extension of wing is deflected slightly to the north (with reference to centre line), thus increasing the width of channel at entrance to 170 feet.

The north pier skirts and upholds the spoil bank below Lock No. 15, and lying between it and the new entrance.

The south pier is 75 feet south of, and parallel to centre line, its east end, distant about 310 feet from the lock, is returned south at right angles, and forms a block 50′ × 32′ whereon to construct the ice-breaker.

From the ice-breaker a rip-rap wall with a slope of 2 to 1 extends in a straight line west to Potash Point, enclosing and protecting the triangular-shaped embankment formed below it and in rear of south pier.

An eddy from N. E. to S. W. sets obliquely across the present and the new entrance it may be corrected, if considered necessary, by extending the north pier about 300 feet.

The best way to approach the new entrance is from the south or Island side of the channel instead of following the north shore past Urquhart's Point, as at present done.

With buoys off Cornwall Island, and range marks and lights on Potash Point, the new entrance will be perfectly safe and easy of access at all times for vessels bound up the river.

So far as observed during the past two winters, the new entrance was not affected by the movement of ice.

The south pier and embankment, with the outlying shoal formed by dredging operations, seems to have protected it effectually.

Lock No. 1, or entrance lock. The tail bay is placed fully 50 feet inside, or west of high-water mark, the lower hollow quoins being nearly at right angles to the head bay of Lock No. 15.

The length of walls on floor is 361′ 7″ and the width between them in the recesses 51′ 7½″. Their height is 30′ 5″. Lift during extreme low water 13′ 3″.

The general dimensions or gauge specified for the enlarged locks, viz., length from centre to centre of hollow quoins 270 feet, width between the chamber walls 45 feet at the level of 14 feet above the mitre sills, has been adhered to.

The lock pit was dredged to within 3 feet of bottom, and when unwatered and enlarged to its full size, proved to be free from springs.

The bottom, indurated clay, was uniform throughout.

The foundation was formed in all respects as directed in the specification.

A stratum of concrete at least 12 inches thick, deposited in two courses, covered the entire bottom of pit; upon this timbers were bedded transversely, and levelled on five ranges of longitudinal sub sills, the intermediate spaces being filled with concrete. A floor of 3-inch plank was next laid and treenailed to the timbers, and in the space between the walls a second covering of 2-inch plank broke joints with and was spiked to the floor.

The mitre sill platforms and mitre sills were constructed exactly as specified, as also the sheet piling, trenches, etc.

In addition, the timbers in the tail bay were anchored on centre line in a concrete trench, and also in the lower transverse trench of the foundation.

Also all voids in the mitre sills were filled with concrete and decked with 2-inch plank.

Puddle walls in rear of the lock walls were formed as required in the specification.

The finished level of mitre sills is 4·50 feet +; level of coping of walls 33·84 feet +; and of breast wall 16·25 feet +.

Radius of wings in head and tail bays, at level of coping, 30 feet.

In the tail bay, steps have been formed in the thickness of each wing wall, descending from the coping of the lock to that of the piers on either side of the entrance channel.

Above the coping of the piers the extension of wings is semi-circular and level with coping of lock walls.

The upper wings are extended about 90 feet above the lock, curving inwards with a gradually increasing batter to connect with the slope wall lining of the basin.

The Basin or reach between Locks Nos. 1 and 2 is 849 feet in length, with a width on bottom of 122 feet; its sides are protected by a slope wall built of quarry stone, laid dry at an inclination of $\frac{1}{2}$ to 1, and coped horizontally with dimension stone.

Towing paths 20 feet wide. exclusive of surface drains; are formed in cutting on both sides of the basin, and finished level with coping of slope walls, 35·75 feet +.

Top-water line is 31·75 feet +, and the bottom of basin 16·75 feet +.

The continuous line of the towing path and slope wall on south side is broken by the lower weir and tow path bridge at a point 185 feet below Lock No. 2.

Lock No. 2.—The lower hollow quoins are placed opposite and nearly at right angles to the upper gates of Lock No. 17.

Its dimensions are the same as in Lock No. 1, and the lock-pit, when completed, afforded an equally solid foundation, but was more difficult to form owing to springs in the bottom and to the stony character of the excavation.

The description of the foundation of the entrance lock will apply in every particular to that of Lock No. 2, except as to anchoring the timbers in the tail-bay, which was omitted here.

The level of mitre sills as finished is 17′·75 +. Coping of lock walls 47′·00 + and of breast wall 29′·50 +.

Lift 13′3″ from top-water line in basin to level of Cornwall Reach, when raised two feet as contemplated.

Radius of wings in head and tail bay 30 feet, as in the entrance lock.

The lower wings of this lock have no steps, the descent from the coping to the towing path is by a ramp having a grade of 1 in 15, corresponding to the finished level of the coping of the lower raceway wall, which serves to retain the south side of it.

The extension of wings in tail bay will conform to the lines and level of slope wall in basin and also to the coping of lower raceway. But the upper wing extensions, with a similar batter (not exceeding $\frac{1}{2}$ to 1) will cross the slopes of the banks obliquely, curving inwards to conform to the regular lines of the canal at the level of top water, 45 +.

The Regulating Weir, etc.

1st. The Towing Path Bridge is located 270 feet above Lock No. 2 and forms the inlet to the upper raceway from the canal.

The width between the abutments at bridge seat is 40 feet, including a centre pier.

Level of coping 49'·00 + ; foundation, 29'·50 + .

2nd. Upper Raceway, constructed parallel with the centre line of locks and basin and 122 feet south.

Its width at the level of coping is 34'3". The side walls have a batter of 1 in 8 and are built of a large class of rock-faced stone laid in cement, for the most part in regular courses but with occasional checking to permit of a change in thickness.

The walls are founded in trenches excavated in level stratified clay 2'6" below bottom of present canal, i.e., to the level of 29'·50 + . The south wall is puddled in rear from the canal down to the weir.

An embankment sixteen feet wide, in continuation of the south bank of canal, is formed in rear of south wall, the entire length of the raceway. The level of the coping is 47'·00 + , uniform with Lock No. 2. Top-water line 45'·00 + . Bottom of raceway as finished 31'·50 + . Bottom of side walls 29'·50 + or 2'6" below bottom of present canal.

3rd. The Weir is composed of a breast wall, centre pier and abutments, with cross wall and checks for stop logs above the breast.

Splayed wings connect the abutments with the walls of the upper and lower raceways. The breast wall is built of cut stone, and has six sluice-ways 4' x 4' through it. The spill-way is 47'6" in length, exclusive of the centre pier. The coping of breast is finished 44'·50 + , or 6" below top water line in canal.

The upper side of the breast wall is vertical, and is placed exactly at right angles to the centre of lower chain wells, lower recess, Lock No. 2. The breast and abutments of the weir rest upon a foundation of timber and plank, the spaces between the timbers being puddled, except under breast wall and apron, where concrete has been substituted.

The ranges of sheet piles and puddle trenches are built as specified, except also the trench under breast, which is filled with concrete. The abutments and wings are built of rock-faced masonry.

The coping of abutments is raised 15" above the level of raceway walls, and is checked to enclose the foot bridge above breast. Puddle walls have been formed in rear of abutments for their full height.

The level of the floor, or apron of weir, is 24'·10 + ; sills of stairways 26'·10 + , and the top water line below breast wall 31'·74 + as in basin.

4th. The Lower Raceway connects the weir with the lower weir and the discharge race. The foundation of these structures is of timber and plank, puddled in the intervals between the timbers as described above. It is raised three feet higher than that of the weir by a cross wall between, and bonded into the abutments. Splayed wings, recessed and lined with 2-inch plank, connect the abutments with the side walls of the raceway, which are similar to those before described in the upper raceway.

The centre line is also parallel to that of the locks, and 122 feet south from it.

In making the descent from the weir to the lower weir, the coping of the side walls has an inclination of 1 in 15.

The width between the walls at the coping, from the angle of the splay, is uniformly 40 feet.

These walls at the level of the lower weir, are returned at right angles, on the north side, to the west abutment of lower weir, and on the south, far enough to form the west abutment or side wall of the discharge race.

The wall at the east end of the raceway, opposite to, and parallel with breast wall of weir, connects the east abutment of lower weir with the side wall or abutment of the discharge race.

This wall is also recessed and lined with plank.

The level of coping is 35'·75 + and the side walls, where returned, finish at the same level.

The level of the floor of raceway is uniformly 27'·15 + .

5th. The Lower Weir consists of abutments, breast wall and centre pier, the masonry of which is similar to that of the weir.

It rests on a foundation of timber and plank, with concrete filling between the timbers and in the sheet pile trench under the breast.

The space between face of excavation and rear of breast wall was also filled in with concrete to level of raceway floor.

The centre pier is 186 feet east of Lock No. 2.

The weathered ends of the abutments correspond with the lines of slope wall in basin, and the coping with the level of the towing path 35'·75 + .

The width between abutments at the bridge seat is 40 feet.

Here the towing path bridge must be so constructed as to withstand the fluctuation of the ice.

The breast wall is built without sluice-ways, it has a spill-way of 35 feet exclusive of pier.

Checks for stop logs on breast have been formed in pier and abutments.

The level of coping of breast is 31'·00 + , and the level of floor or apron under breast and abutments corresponds with that of bottom of basin 16'·75 + .

6th. The Discharge Race is situated in the south-east angle of the lower raceway and directly opposite the lower weir.

The breast-wall of cut stone is 3 feet in height and has a spill-way of 38' 6" ; it is built parallel with centre line and connects the east or end wall of raceway with the return of the south wall.

Checks for stop logs on breast have been cut in the side walls.

The level of coping of breast is 30′·15 +, and that of the side walls or abutments 35′·75 +.

The foundation, which is upon the same level, and constructed in the same manner as that of the raceway, is extended about 15 feet south of the breast-wall and there forms an apron, protected and secured by a row of sheet piling in a trench filled with concrete.

From this point, the discharge, an open cutting is continued south at right angles to centre line of raceway, across Potash Point to the river. The cutting will be about 550 feet long and 13 feet deep, with a fall of 15 inches.

The base of slopes in this cutting will require to be protected with stone, as also the bottom near the apron.

The Sewer commences at the south end of tunnel where it joins the corporation drain and thence runs in a straight line to the river above Potash Point, a distance of about 395 feet. It passes at the required depth below the bottom of the new canal, and is constructed according to specification.

The opening is 3 feet in height and 2′ 9″ wide.

The level of sill at outlet in river is 21′·00 +.

Towing Path and Canal proper.—East of Lock No. 2 the towing path is formed in cutting on both sides of the basin. It is 20 feet wide, exclusive of side ditches, and 19 feet above bottom, or 35′·75 +.

Above the lock the canal is 100 feet wide at bottom, in cutting, with side slopes of 1½ horizontal to 1 vertical.

The north bank, at a point about 450 feet west of Lock No. 2, connects with the present towing path at the waste weir by a curve of 1120 feet radius.

The south bank or towing path is fully 20 feet wide on top. From the bridge over inlet to upper raceway it curves to the south with a radius of 5,730 feet, and joins the old bank at a point about 400 feet east of end of section.

The connection between the two banks has been carefully benched and puddled.

As a rule the seats of all banks were mucked and cleared of all improper materials and, where necessary, benched strictly in accordance with the specification.

The whole of the exterior slope of the new bank, from near the towing path bridge to head of section, is protected by a well built rip-rap wall.

The level of bottom of canal is 32′·00 +, top-water line 45′·00 +, and towing path 49′·00 +. Level of water in St. Lawrence at base of south bank about 21′·00 +.

Right of Way.—The whole of the land on Potash Point, south of the present canal limits, was taken possession of by the Government shortly after the commencement of the works, and has since been used as service ground by the contractors.

Works connected with the present Canal.

The raising of the water level two feet in the Cornwall Reach renders it necessary to raise the walls of Lock No. 17 to the level of 47′·00 +, uniform with Lock No. 2 of the enlargement.

The south bank or towing-path west of Lock No. 17 to the old waste weir will also have to be raised to the level of 49'·00 +, and the remainder of it from thence to its junction with the new bank, together with the tunnel and waste weir, removed.

The banks of the north side of the canal and head race to the mills, including the superstructure of supply weir, must also be raised and strengthened, and a new bank formed across the north approach to the tunnel.

I will now advert to the progress of the works since their commencement in

1876.

Ground was broken on the 2nd September. The seat of south bank was stripped and benched. Sewer pit excavated, and work begun in Lock-Pit No. 2 and in prism of canal west. Work commenced at Cornwall Quarry September 26th. The sewer was completed during the months of October and November.

Work on the section closed for the season 30th December.

1877.

Highest water during winter of 1876-77, 39'·00 +. Work at Cornwall Quarry continued throughout the winter.

Work on section commenced April 28th and closed in December.

Work was begun at Maitland Quarry in April, and the stone therefore delivered at the G. T. R. station and from thence hauled to section.

For this purpose a roadway was formed through the tunnel in June, the canal bridge proving unsafe for the passage of stone teams.

Lower entrance dredging was commenced on the 21st May, and discontinued November 24th.

In addition to the work of deepening the new entrance channel, the dredge excavated a gullet through the natural dam into Lock-Pit No. 1.

Both lines of cribs forming the sides of new entrance were sunk and filled with stone before the close of the season, and the bulk of the material dredged placed in rear of the south pier.

Before the season closed, Lock-Pit No. 2 was bottomed, also the prism of canal west of it, and considerable work done at the basin.

The excavation for regulating weir, etc., was also finished during the season.

The towing path embankment west of Lock No. 2 was raised to its full height and width throughout except a short stretch over the side of the old discharge race.

The greater portion of the exterior or river slope of this embankment was rip-rapped.

The upper raceway and bridge, the weir and about two-thirds of the lower race was completed by the 22nd of November, when masonry was stopped for the season.

The masonry in upper raceway was commenced June 4th.

1878.

The highest water noted during the winter of 1877-78 was 34'·00 + .

Dredging on lower entrance and lock pit recommenced April 9th and was completed by the end of May.

Early in July a coffer dam of timber and clay was constructed across the lower entrance channel about 50 feet east of Lock No. 1.

1878.

The embankment from the east end of south pier was completed to Potash Point with the material from Lock Pit No. 1, dredged and excavated after it was unwatered.

The foundation of Lock No. 2 was commenced June 1st, and finally completed August 26th. In consequence of heavy rainstorms and of its not having been sufficiently loaded, the floor of chamber rose slightly near the upper mitre sill, whilst that of the upper recess floated; this latter was torn up and rebuilt but the chamber floor was got home without much difficulty.

With this exception, nothing occurred during construction to impair the successful completion of the lock foundations or walls; lines and levels were scrupulously adhered to by the contractor throughout.

The foundation of the entrance lock was commenced August 31st, and completed November 1st.

The masonry in lower raceway was resumed June 17th, and all works connected with the regulating weir finished by the 30th July.

Lock No. 2.—Masonry commenced in the lower recess August 8th, and ten courses were laid by 10th of October, when work was suspended.

Lock No. 1.—Masonry commenced here October 14th in the upper recess, and at the close of the season (12th November) three courses were completed and the fourth began: the walls were then flooded to protect them from frost.

Excavation, etc.—The towing path was finished during the season, also both lock pits and considerable progress made in the basin, the western end having been bottomed.

The embankment and puddle in rear of lock walls, etc., usually kept pace with the masonry.

The rip-rap wall on towing path was completed to level of top bank.

The greater part of the stone used in the face of the lock walls consisted of the blue stone from Cornwall quarry, whilst the backing was principally from Maitland.

Of the face stone from Maitland quarry a part only was used, and then always below water line. It was found that exposure to the weather developed drys and other defects, for which reason its use was discontinued.

The cement used was from Oswego, N.Y.

1879.

The highest water observed during the winter of 1878-79 was 38'·00 +.

Advantage was taken of exceptionally low water to build the rip-rap wall outside the south embankment, also to prepare the upper surface of the piers to receive the superstructure of which the ice-breaker on south pier and about 200L feet of wall on north pier has been built.

The piers and superstructure forming the extension of lower wings of Lock No. 1 have been nearly completed.

Masonry re-commenced at the entrance lock on May 15th, and was finished to level of under side of coping the 5th of August.

In the upper lock masonry commenced August 15th, and was completed to under side of coping September 23rd.

Both mitre sills of entrance lock were filled with concrete and covered with 2-inch plank.

The segment plates and all castings and fixtures connected with the chain walls were also placed in position before the water was allowed to rise in the lock.

The stone (blue limestone) used in the face of the lock walls and other structures is obtained from the McLeod quarry, on Lot No. 4, in the 4th concession of the Township of Cornwall, near the quarry from whence the stone of which the old locks are built was procured.

The beds are thick and afford courses of 24 inches, which are perfectly free from drys or shakes, etc., and fully equal in every respect to the very best samples of the stones used for face work in the present locks on the Cornwall Canal.

The courses in the new locks average 18 inches in thickness, exclusive of coping, which is respectively 16″ and 17″.

One barrel of Oswego cement laid on an average 2·40 cubic yards of masonry.

The concrete used in foundations was made as follows: Cement 1, sand 2, and broken stone 4 parts.

The coffer dam at foot of entrance lock is now no longer wanted, and preparations have been made to remove it.

In the basin about 560 feet in length of slope wall has been built on the south side, extending downwards from the lower weir to where it joins the extension of south-west wing of Lock No. 1.

The extension of wing has also been completed to level of outside of coping.

Masonry was suspended for the season on November 19th.

The Maitland quarry was finally closed at the end of July, and all plant removed to Cornwall.

The earth work done this season has been chiefly in the basin, but some progress has been made with the cutting forming the outlet of the discharge race.

All material excavated has been placed in embankment in rear of locks and other structures, or used in forming the north bank west of Lock No. 2.

The only interruption to the progress of the work has been caused by the periodical rise in the river during winter, flooding the new canal and basin and thereby retarding the commencement of excavation in the spring.

The sewer has hitherto served a good purpose by carrying off all water above the level of the outlet in the bay above Potash Point.

In November two laborers were killed by a fall of earth in the basin. This is the only fatal accident which has occurred since the works commenced.

The work which remains to be done comprises the whole of the "various works connected with the present canal, including raising walls at Lock No. 17 and supply weir, the banks of canal and head race to the mills, the removing of tunnel and waste weir and of a portion of the south bank or towing path," also the undermentioned unfinished work on the enlarged canal, viz: The coping for both locks; superstructure of south pier entrance channel; extension of wings (5) both locks, and slope wall north side of basin. Excavation in north slope of basin; towing paths in cutting; discharge race; north side of lower entrance; the removal of coffer-dam and some spoil bank in prism of canal; five cribs of various lengths at lower entrance connected with the regulating wier; two towing-path bridges and one foot bridge required; also sluice gates and fixtures.

Snubbing posts for locks, basin and lower entrance.

The foregoing report, it is hoped, contains the required information, details, etc., for future reference.

I have the honor to be, sir,

Your obedient servant,

TOM S. RUBIDGE,

Engineer in charge.

JOHN PAGE, Esq.,

Chief Engineer of Canals,

Ottawa.

APPENDIX No. 34.

EXTRACT FROM CHIEF ENGINEER'S REPORT, DATED JULY, 1874.

Channel through Lake St. Francis, etc.

From the outlet of the Cornwall Canal to Glengarry Point, near head of Lake St. Francis, a distance of fully five miles, there are for the most part two different channels, the principal one of which is fully 700 feet wide throughout, and at least twenty feet deep. From the latter place to the "Narrows," and south of Clark's Island, a stretch of two and a half miles, there is a water way thirty feet deep and 1,200 feet wide, north of what is called Grass Island. Thence to Summer's Island, one and one quarter miles, there is a depth of fully twenty two feet and a width of 500 feet north of Craig's Island. From Summer's Island, three and three-quarter miles, to Squaw Island, there is a width of 1,200 feet and a depth of twenty feet, except at the places and for the extent mentioned below, viz:—

1st. A shoal of boulder stone, etc., abreast of St. Francis Island, called the "Middle Ground" on which the depth below the assumed low-water line is seven feet, and the material to be removed to give a depth of fourteen feet, which would be about 10,500 cubic yards.

2nd. There is what is called the "Highlander" Shoal, lying towards the northern side of the channel, and abreast of L'Islet, with about ten feet of water over it, so that to obtain a depth of fourteen feet would require the removal of 1,450 cubic yards, chiefly of boulder stone.

3rd. Removing part of north side of "Horse Back" Shoal; and the south-west point of "Squaw Island Flats," which in the aggregate would amount to about 2,500 cubic yards of clay.

At other places, as above stated, the water is sufficiently deep, but these shoals, from their position, would doubtless be found dangerous to vessels at night or in foggy weather unless marked out in a manner that would be likely to cost fully as much as their removal.

From Squaw Island (one mile south-west of Lancaster light) to the floating light at the Traverse, three and three-quarter miles, the channel is 1,150 feet wide and over twenty six feet in depth.

Thence it crosses Lancaster Bar, through what is called South Gully, towards the south shore nearer Dupuis' Point, a distance of one and one-half miles, in which the least depth of water is twenty feet, and least width 700 feet.

From opposite the latter place (Dupuis' Point,) three-fourths of a mile west of Cherry Island, the channel is fully 1,800 feet wide, and at least twenty three feet deep throughout, straight for about five and three-quarter miles, or until nearly abreast of the lighthouse on McKee's Point, which is a little over twenty three miles from the foot of the Cornwall Canal.

Vessels bound to the Beauharnois Canal generally cross Port Louis Flats at a point about one and a half miles to the westward of McKee's light, but those intending to descend the rapids follow the north, or deep-water channel to the foot of the lake.

At periods of low water, or indeed at any other time, vessels drawing twelve feet water, as contemplated for the enlarged scale of navigation, could not cross Port Louis Flats, consequently the north channel must be used for at least two miles below McKee's Point, when a course may be steered for fully six miles towards the light situated about one mile and a third above the head of the Beauharnois Canal.

From opposite Grosse Point to within 2,000 feet of the canal entrance, a distance of one mile and a third, the present channel is at many places narrow, intricate and difficult to navigate even by the class of vessels now in use.

This locality, it may be stated, is open to the sweep of westerly winds, hence the water-way to be at all times servicable should be nearly straight, or at all events have flat, easy curves, and be from 250 to 300 feet wide, and have a depth of not less than from thirteen and a half to fourteen feet under low-water mark. In doing this, the ten feet water line at the first bend above the canal entrance might be assumed as the south side of the enlarged new channel, and the south side of the pier on which the upper or red light stands as the north side of the line; thence curving gently to the north through the shoal off Grosse Point.

To carry out this proposition, the work to be done, and the approximate cost would be as follows:

The shoal first in ascending order would require the removal of 31,000 cubic yards clay and gravel in which there are fully twenty two per cent. boulders.

Second shoal, 46,000 cubic yards clay and gravel, including eight per cent. boulders.

Third shoal, 61,000 cubic yards indurated clay and gravel, including thirty four per cent. boulders.

Fourth shoal, 3,000 cubic yards clay and gravel.

The probable cost of executing these works, together with lights, buoys and beacons, would amount to $430,000.

There is, however, reason to believe that the difficulties connected with the existing approach might be obviated by making the entrance either at Knight's Point or at Grosse Point, and continuing the line downwards to the south of the Village of Valleyfield until it enters the basin, situated about a mile and a third below the guard locks.

Lake St. Louis, etc., etc.

From the lower end of the Beauharnois Canal to the upper lightship in Lake St. Louis, a distance of about ten miles, the channel is at no place less than 2,000 feet wide and its least depth is twenty three feet.

The lightship referred to is moored near the upper part of a series of detached shoals, which occupy a very considerable space in width, and extend downwards to near the foot of the lake, a distance of about four miles.

A careful hydrographic survey, made of the lake, especially that portion of it for five miles above Lachine, indicates that the shoals are of irregular height and dimensions, generally with deep water openings between them.

Still they are so situated that there is no direct channel through or amongst them adapted to the enlarged scale of navigation.

In fact the line at present used seems to be the only one that will admit vessels of nine feet draught passing at low stages of the water, and to do even this pilots have to keep an unusual distance outside the range between the lights.

It is believed that the upper light is probably in the best position that can be selected, but the middle one should stand further to the south, otherwise the channel should be on the south side of it.

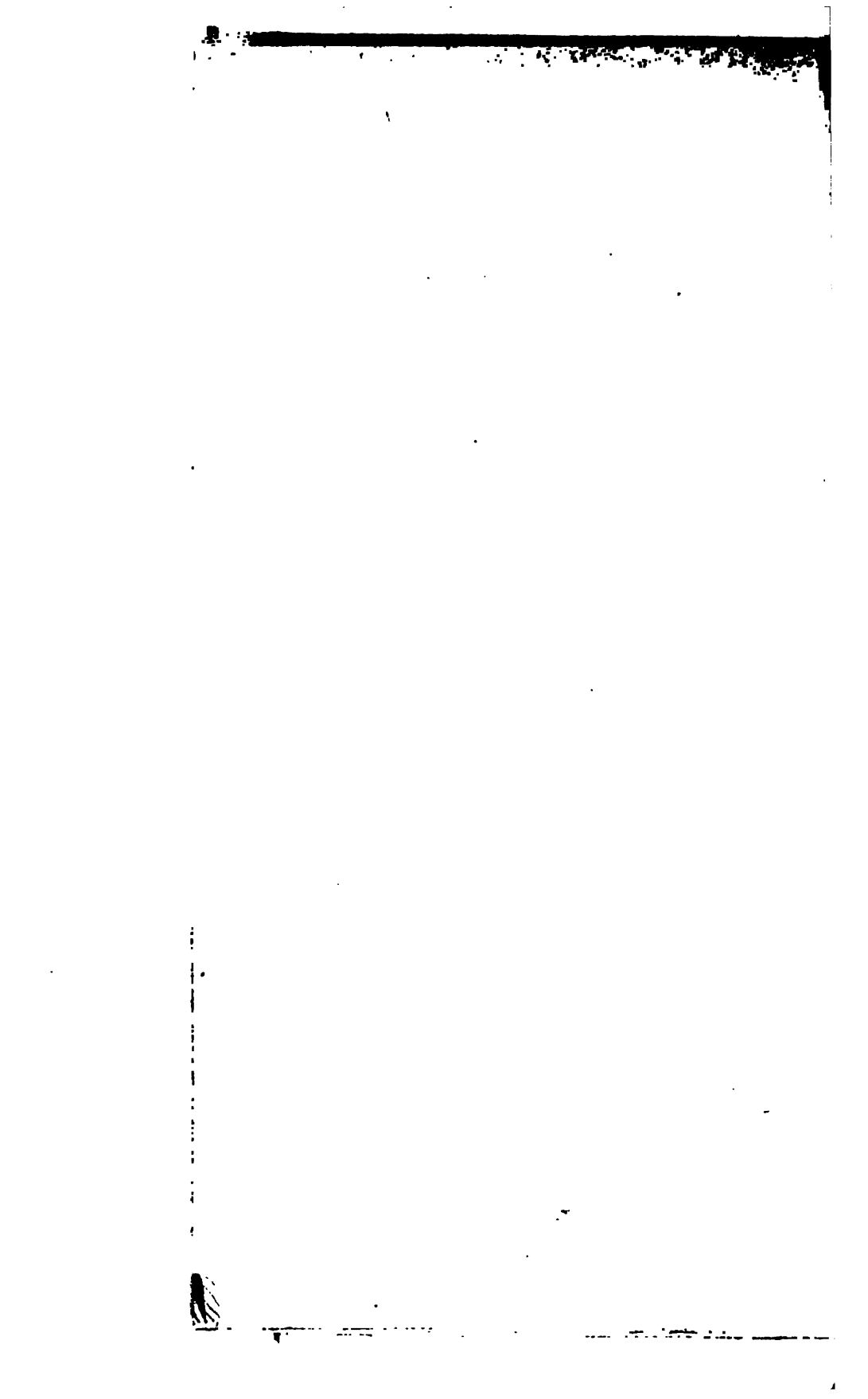
The position of the lower light might also be changed advantageously for the new line, and be so placed that the north side of the channel, after the necessary improvements have been made, will form one continued straight line up to the middle light.

To admit of this arrangement being satisfactorily carried out, all shoal patches and the points of any shoals that project into, or in any way interfere with a channel of 600 feet in width, should be entirely removed to a depth of fourteen feet below low-water line.

To do this from the entrance of the Lachine Canal upwards, would require the removal of about 165,000 cubic yards of material, of which there would be 110,000 cubic yards of indurated clay, mixed, so far as could be ascertained, with about forty per cent. of boulder stones; the other 50,000 cubic yards would be of ordinary clay and sand overlying at irregular depths a hard class of material.

The probable cost of this work, including buoys, etc., would be about $520,000.

110 000. 4'6 @ 90 = 495 000
50 000 @ 50 = 25 000
520 000



APPENDIX No. 35.

LACHINE CANAL.

SPECIFICATION for the Construction of Two Locks, a Basin, Weir, etc., at the MONTREAL Terminus.

It is proposed to form another entrance to the canal from Montreal Harbor, on the outer or river side of the existing one. For that purpose two locks are to be constructed, and a basin formed between them, a weir and bridge abutments built, and such other works executed as hereinafter described.

The works are to be situated in the respective positions shown on the general plan exhibited, but the Department of Public Works reserves to itself the right of changing the location of any, or all of them, as much as 200 feet in either direction from the place represented, or of altering the dimensions of the structures themselves.

These changes may be made either before or after the works are commenced, or at any time during their progress, without giving cause for any increase or diminution in the prices tendered for the different items of work.

The entrance lock will be placed so that its upper gate-quoins shall be nearly opposite those in the present outlet lock, at which place the respective centre lines will be about 180 feet apart, and at the head of No. 2 Lock they will be 100 feet apart.

The locks are to be 270 feet in length between the gate-quoins, 45 feet wide at bottom, and arranged so as to have 18 feet depth of water on the mitre sills.

A basin 540 feet long, and 260 feet wide, is to be formed between the locks, and made of an uniform depth of 19 feet below surface water line, or 1 foot under the top of the sills.

The immediate entrance to be from 80 to 100 feet in width, and the bottom sunk at least 1 foot below the top of the new mitre sills, the sides to be of crib work, carried to the height of the harbor wharves.

The surface of the ground, where the pit for the outlet lock is to be excavated, is at present from 6 to 10 feet over low-water mark, and liable to be inundated for the greater part of the winter and spring months.

It was made up of material dredged from the harbor and dumped into the water on the natural bed of the river.

For the space to be occupied by the lower locks, as well as for the basin, this material must be removed, and the original bed of the river sunk to admit of the lock foundation being placed at the required depth, and the basin formed as above stated.

To effect these objects in an expeditious manner, the contractor must keep the work fully unwatered during its progress by pumping or otherwise.

The second lock will occupy part of the site of the combined locks that formed the outlet of the old canal, the north walls of which it is intended shall remain intact and be thoroughly underpinned at such places as may be necessary. The additional width required for the lock pit and entrances to it, is to be taken off the south-east or river side, and the stone from the old walls, where suitable for backing, may be placed where they can be readily got at for use in the new structure.

The material excavated from the lock pit, basin and entrances must be placed so as to make up the necessary embankments on both sides of the work, and the side walls of the basin are to be carried up before the centre portion of it is excavated, so that the material can be advantageously used for filling where required.

When forming the embankments in rear of the lock, weir and basin walls, or wheresoever directed, the material must be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time, and if the works be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

The contractor must, in all cases, provide his own service ground, and in the prosecution of the works, the operations must be conducted in such a manner as not in any way to interrupt or endanger the navigation of the canal.

The work will be let in items, as stated in the printed forms of tender, which must be strictly adhered to, as no offer will be accepted unless in accordance therewith.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock;" the former to embrace all kinds of material found in the cuttings, except absolutely connected "quarry rock," and boulders containing more than one-third of a cubic yard. The prices tendered for these items to cover the entire cost of removing the materials, forming and finishing up embankments, and completing everything connected with the excavation of the basin, lock pits and entrances to them in a workmanlike and satisfactory manner, agreeably to the design contemplated.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

LOCKS.—The locks, as above stated, are to be 270 feet in length between the gate-quoins; 45 feet in width between the side walls at bottom, and the mitre sills are to be placed so as to have a depth of eighteen feet water over them, *i.e.*, the sills of each of the new locks are to be arranged so that their tops shall be two feet lower respectively than those at the lower gates of the present locks (Nos. 1 and 2).

The faces of the walls are to be of dressed stone, backed up with large flat-bedded stones, laid throughout in hydraulic cement mortar, and placed on a foundation of timber and plank, prepared and arranged as hereinafter described.

The pits excavated for them are to be of suitable dimensions to admit the side and wing walls, and made to correspond with such lines as marked out by the officer in charge. The bottom in each case must be made level and smooth at the proper height to give an uniform bearing for the foundation timbers.

The materials excavated from the pits, basins and approaches must be hauled, deposited in embankment at the places and in the manner previously stated.

In excavating the pit for the second lock, the present north wall of the old locks is, if possible, not to be disturbed; and where necessary to sink deeper than its foundation, the material under it must only be removed in short stretches at a time, and the underpinning of that portion be extended as far underneath as practicable, and fully carried up so as to give a proper support to the wall above before another stretch is dug out.

If found necessary to remove the upper or any other part of the old wall referred to, for the new works, it must be done by the contractor to such an extent, and in such a manner as the officer in charge may direct.

FOUNDATION TIMBERS—to be of pine 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up the distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock, and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid; be well filled with the best description of puddle, well cut and rammed; or if directed, the spaces, and at the ends of the timbers, must be made up with concrete, their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle or concrete as may be required.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square and of a length to reach from rear to rear of the walls, all of which must be counterhewn, and well jointed with a plane, so as to make water-tight

joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts (1½ inches diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, ETC.—Five or more trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed 2½ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best materials for that purpose which can be obtained within one mile of the work, and must be cut, mixed, prepared and laid as directed by the officer in charge. Ranges of sheet piles, are also to be placed in the foundation of the chamber if so directed.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank: the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every three feet in width of planking, in both courses, must break joints at least 4 feet, and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inches diameter, two in each end of a plank and on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid, the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned, and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 50 feet long, let 2½ feet into the wall at each end. They, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 17 inches, checked 1 inch into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 1 inch deep, 2 inches in width, is to be cut in the lower edge of the mitre sills, to receive the upper part of the ends of the first course of planking.

Before they are put together, all the mortises, tenons, and joints must be well coated with white lead; and when about to be placed in their berths a strip of canvas, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half ($1\frac{1}{2}$) diameter, have upset heads, and be well ragged at the point.

MASONRY.—The locks are each to be 13 feet lift, and the side walls carried up to 2 feet over the surface water level of the upper reach with which they are connected, or to a height of 34 feet. The chamber walls are to be 11 feet wide at the bottom, with counterforts in rear, 6 feet long in line of wall and 3 feet projection, placed not more than twelve feet apart; the recesses are to be 2 feet 8 inches deep at top, and the walls 11 feet wide at bottom.

The face of the chamber and wings are throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the locks must be built of approved, sound and durable stones; those which form the face work must be free from drys, seams or other defects, and must be at least equal in every respect to the best class of stones used in the existing two lower locks.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of a lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed $\frac{3}{16}$ of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted) laid so that the beds and end joints shall not exceed $\frac{3}{8}$ of an inch.

CUT STONE—to be neatly dressed and boucharded; made square, bevelled, or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than 2 and 3 feet depth of bed in the alternate courses.

In each course must be headers of at least two feet length of face, and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible midway between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond, in rear of the face stone, is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least 1½ times their height, and the headers 2¼ times their height; and in all cases the tail of a header must have a width of ⅔ the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least 4½ feet face and 5½ feet depth of bed; the latter 5½ feet face and 4½ feet bed. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downward at a rate corresponding to batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet, and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN HOLES.—There are to be eight chain wells in the positions indicated on the plan; each well will be 2 feet square inside, and the man-holes from them to front of the lock walls, are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chain are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

CHECKS.—For reception of stop timbers, two checks are to be formed in the faces of the lower wing walls of both locks, and at the upper wings of the entrance lock; they are to be arranged as shown on plan, be 2 feet apart, 12 inches wide and 6 inches deep at the top, and made plumb in the rear.

GUARD GATES.—At the head of the second lock the wings are to be continued about 30 feet upwards on a foundation of timber, concrete and plank placed at the height of 9 feet over the level of the lock mitre sills.

In the face of each of these walls a recess is to be formed for the reception of a guard gate, arranged to stand vertically when required, and to occupy a horisontal position when not in use.

A range of sheet piles is to extend across the entrance, and from rear to rear of the walls at the upper side of the recess for the gates, and another at the breast wall of like

dimensions; both courses are to be placed and secured as described for those at other parts of the foundation.

The top of the breast wall of this (the second) lock, is to be formed of oak timber 12 inches square, and not less than 50 feet in length, well jointed, laid close and fastened to the masonry underneath with foxed-wedged bolts one inch and a half diameter, three through each timber, and all of them made of such lengths as may be directed.

The timber at the upper edge of this platform must, however, be of white oak, not less than 20 inches square, of sufficient length to extend 3 feet into the wall on each side; the upper edge to be hollowed out to receive the lower side of the stop gate; it must be secured to the foundation timbers on which the breast wall is placed by means of shackle-bolts, 2 inches diameter, part of which must be arranged so as to form anchors for the collars attached to the gate.

COURSED WORK—for the face of the chamber walls may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed $\frac{3}{8}$ of an inch.

BACKING—to consist generally of large well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the facework.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin wedged-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—of the chamber recesses and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear, and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top, and two feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

The ascent from the coping of the lower lock to that on the east side of the basin is to be made by means of steps, not exceeding 9 inches rise, cut out of the solid for the full width of the coping; treads to be of an uniform width of at least 12 inches.

Steps of similar dimensions and of a like length (4 feet) are to be cut out of the solid, to form the ascent from the coping of the basin to that of the second lock, arranged, laid, placed and secured in like manner as those at the lower end, on the east side of the present lock (No. 2.)

In rear of these steps in both cases, and for such a distance as may be necessary to support the roadway to be formed between the locks, a wall is to be carried up of a like class of dressed stone and masonry as that in the upper part of the basin, and covered with coping 3 feet in width, laid at an angle to suit the grade of the road.

Breast Wall—to be of coursed masonry, 9 feet wide at bottom, carried up plumb in the rear and battered to a width of 6 feet at top, and covered with large flat-bedded, scabbled and well-jointed coping stones. The top of the breast wall coping at the outlet lock is to be 6 inches lower than the bottom of the basin, and that above the second lock is to be of a height to receive the platform to be placed immediately below the guard gate.

The Basin—is to be excavated to such a length and width as may be necessary to admit of building the dock walls, and leave the full inside dimensions previously stated (540 by 260 feet).

The side or dock walls are to be of masonry, laid in hydraulic cement mortar, on a foundation of timber and plank, placed so as to be one foot below the bottom of the basin.

The timbers forming the foundation are to be of pine 12 inches square, in lengths of from 30 to 50 feet, counterhewn, laid longitudinally in five continuous ranges—one corresponding with the front line, and another with the rear line of the respective walls—the other three intermediate ranges being placed so as to leave the intervening spaces nearly equal; a timber is also to be placed at the rear line of each counterfort. They must all be laid so that no two joints on adjoining ranges shall be nearer than 6 feet of each other; and in all cases the timber must rest uniformly on the bottom throughout their entire length.

All the spaces between them must be filled with the best description of puddle, well cut, rammed and pounded, or with concrete, as may be directed.

The top of the timbers when laid, if required, must be dubbed to an uniform surface to receive the covering, which is to consist of 3-inch pine plank laid obliquely to close joints, and secured with 7-inch pressed spikes, two at each end, and one at every crossing of a timber.

A range of sheet piles is to be placed along the toe of the dock walls for the whole distance, or to such other extent as may be required; where used they are to be of like dimensions, secured, and the trenches made for them filled, in the manner described for those in the locks.

For the side walls of the approaches, etc., above the second lock, foundations, similar to those above referred to, are to be prepared and laid at a like depth below the water surface as that above stated.

Dock Walls.—Alongside the basin between the locks, and for the approach above the second lock, walls are to be built to correspond with the lines represented on the plan. They are to be 9 feet wide at bottom, with counterforts in rear 6 feet long in line of wall and 3 feet projection, at intervals of 12 feet. The face of the wall to have a batter of one in twenty-four, and the back carried up plumb to within 5 feet of the top, where the counterforts will terminate, and the whole batter uniformly to the rear line of the coping.

For 18 feet over the foundation, the face of the walls, as well as those at the upper approach to the second lock, are to be of coursed work, the stones of which are are to be scabbled and dressed so that they can be laid throughout in such a manner as not to exceed five eighths ($\frac{5}{8}$) of an inch mortar joints. They are not to be less than 9 inches in height, but it is not necessary that a course should be continuous of the same height for a distance of more than 20 feet, provided the stones are checked where the course is broken, so as to admit of securing in all cases a bond of at least 12 inches.

The face of the stones must invariably be picked or scabbled to lines corresponding to the position they are to occupy in the work, and in depth of bed and otherwise they must be of like dimensions (20 and 30 inches depth of bed in alternate courses, and have as many similar sized headers 4 feet depth of bed in every course) as described for the chamber work of the locks.

For the upper 4 feet in height, the face of the dock walls and side walls above the second lock, are to be of cut stone of like dimensions, dressed throughout in every respect, and laid to $\frac{3}{16}$ of an inch mortar joints, and bonded as described for the facework at both ends of the locks, *i.e.*, the stones must be at least *two* and *three* feet depth of bed in the alternate courses, with headers in each course 4 feet depth of bed, placed not more than 9 feet apart.

The whole of them must be dressed to the batter of the walls, the arrises kept good, upper and lower beds made parallel, and the end joints kept full for at least two-thirds the depth of their beds. The backs of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

Backing—to be of a like class of stone, and laid as described for the rear part of the lock walls.

Coping Stones—to be 4 feet wide on top, increasing in width downwards, corresponding to the frost batter in the rear and to the face batter of the walls. They must be at least 15 inches in height of course, 4 feet long in line of wall—be dressed

in every respect, and laid to such joints, and be secured with dowels in like manner as described for the coping on the chamber walls of the locks.

ABUTMENTS—and a centre bearing are to be constructed for a swing bridge above the second lock, at the places indicated on the plan. They are to be carried up to within about 2 feet of the water surface with stone of like dimensions, prepared, dressed and laid as described for those of the chamber walls of the locks. For all angles large-sized quoins are to be prepared and properly laid so as to bond over and with each other, as well as with the adjoining stones.

From the height above stated, the face work of the walls connected with the bridge work is to be of cut stone of like dimensions, dressed and laid as described for the upper part of the basin and retaining walls, and carried to the height shewn on plans, recessed, curved and otherwise adapted for the toe and the turntable on which the bridge is to move.

The coping stones to be at least fifteen inches in depth and of large dimensions; those under the turntable to form a circle to support the track-way for the rollers.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed.

All the masonry in the pillars and side walls forming the west approach to the present bridge is to be taken down and rebuilt at the western entrance to the new structure, and similar pillars, walls, etc., are to be constructed on the east side, for which materials must be provided and the necessary work done by the contractor.

WASTE WEIR.—The retaining wall on the east side is, for a distance of about 40 feet, to be formed into a weir for discharging the water from basin No. 2, when such a course is necessary.

This weir is to have an over-fall of about 40 feet, including the space occupied by the centre pier to be built for the support of a bridge, and the platform for working the sluice-gates.

At this place the retaining wall is to be made 12 feet in thickness, without counterforts. On the upper side it is to have the usual batter of one in twenty four, up to the bottom of the sluice-ways, where an offset of 16 inches is to be made. On the lower side the wall is to be plumb, and have an offset of 9 inches to receive the floor of the raceway.

The floor timbers are to be built into the retaining wall, and care taken that a water-tight connection with it is formed.

Immediately below the breast wall the top of the floor is to be 6 inches under the sills of the sluices, thence the race will have a declivity outwards to the river of one inch in a hundred feet.

It is to be cleared out and excavated to a width of 33 feet, and the bottom trimmed so as to give an uniform bearing to the foundation timbers.

These timbers are to be 12 inches square, laid 12 inches apart, and the spaces between them filled with a good description of puddle, well beaten down.

The floor to be of 3-inch pine plank, fastened with white oak treenails 9 inches long, 1½ inch diameter, and a second coarse of plank 2 inches in thickness is to be laid and fastened with spikes between the side walls.

Adjoining the retaining wall the foundation will be 58 feet wide, or of sufficient width to admit of the wing walls being laid to the angles necessary to connect with the side walls of the raceway.

There are to be three or more ranges of sheet piles across the foundation, sunk 5 feet below the bottom of the timbers, arranged, placed and secured in like manner as described for those in the lock foundations.

The masonry of the wings to be of rock work; face stones to be 18 inches and 2 feet depth of bed in the alternate courses; with headers 3½ feet depth of bed, and not more than 10 feet apart in every course, dressed and laid so that the end joints shall not exceed ⅝ of an inch.

BREAST WALL—to be of stones 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, placed not more than 9 feet apart; all of them to be dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side to be plumb, dressed fair and smooth to receive the frame-work of the sluices, and the lower side to be rock-faced work, laid to a batter of about 4 inches to the foot rise.

There are to six sluice-ways through this wall, each 4 feet wide and 4 feet high, the sides of which are to be dressed smooth; sills and lintels to be 6 feet long each, and the thickness of the piers to be made up of one stone the full width (2 feet).

BREAST WALL COPING—to be dressed 6 feet wide on top, increasing in width downwards; the stones are to be well dowelled together.

Wing coping to be 3½ feet wide, to have the beds and joints kept full throughout, and top neatly boucharded.

BACKING—to be of a like class of work as that described for the rear part of the lock walls.

SIDE WALLS—for the raceway to be 6 feet high, 4 feet wide at bottom, carried up plumb on the back and have a batter on the face of 2 inches to the foot rise. They are to be of the best description of rubble masonry; the stones of the face to be properly scabbled to the position they are to occupy in the work.

Two or more counterforts, each 2 feet x 3 feet, to be carried up in the rear of each wall at such places as may be required. Coping to be at least 9 inches thick, and of sufficient width to cover the wall, and must be scabbled so as to lay to close joints.

At the inside foot of the walls of the raceway and wing walls of the weir, angle timbers are to be scribed to the faces of the walls and fastened to the foundation timbers with bolts, in the manner directed.

All the masonry to be laid in the best hydraulic cement mortar.

CONCRETE—where used, must consist of an approved quality of stone, broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

MORTAR.—The whole masonry of the locks, basin, walls, bridge abutments and weir must be laid in mortar made of the best hydraulic cement, mixed

with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them, and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BEDS,—in rear of the lock, basin and retaining walls, as well as at those of the bridge abutments, weir and raceway, to be 3 feet in width, carried the entire height; they must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds, where required at other places, are to be made in a similar way and of such dimensions as may be directed.

The channel between the outlet lock and harbor is to be 80 feet in width immediately below the lock, increasing outwards to 100 feet in width; the north-west side to be on the same line as that of the basin between the locks, and the additional width formed on the side next the river.

The sides are to be of continuous crib work, 25 feet wide, carried to the same height as the adjoining harbor docking, and to which they are to be connected. The entire bottom is to be sunk one foot below the top of the new mitre sills, or 3 feet below those of the present lock.

The pier work, from the foundation up to low-water line, may be built of pine, hemlock, spruce, ash or elm timber 12 inches square, sound and of good quality.

The outer timbers, or those of the face and ends, must be framed and laid so that the horizontal joints between the courses shall be close for at least two-thirds of their length, and nowhere exceed one-half ($\frac{1}{2}$) inch joint.

At the angles they are to be connected by means of double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the sides be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and three-fourths ($\frac{3}{4}$) of an inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, placed not more than 10 feet apart, and so arranged that the ties resting on the respective rounds of timber shall be mid-way between those of the courses immediately below and above. Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, and a rag-bolt $2\frac{1}{2}$ feet long, seven-eighths ($\frac{7}{8}$) of an inch diameter is to be driven through the head of each tie into the timbers underneath.

LONGITUDINAL TIES—10 inches thick are to be framed into and dovetailed between the alternate courses of end timbers, and be secured by bolts in like manner as described for the transverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails 2 inches diameter and 16 inches long.

The ties to be supported on blocks where required.

The bottom of the cribs must be adapted to the place they are to occupy when sunk, and the cross ties in the first full course are not to be more than two feet apart.

Immediately after a crib has been moored in its proper position, a platform must be laid over it of sufficient size and strength to carry enough stone to sink it, and when thus sunk, and ascertained to be at the right place and line, the crib is to be filled with such coarse material from the excavation as the officer in charge may direct.

SUPERSTRUCTURE—to be carried up to the same height as the adjoining dock walls; sides to be of pine timber 12 inches square, in lengths of 30 to 50 feet, laid close. Cross and longitudinal ties to be also of pine 10 inches thick, framed, dovetailed into the sides and ends, notched at the crossings, and be secured with treenails and rag-bolts of like dimensions as described for the crib work underneath.

The top, front and rear timbers to be checked 3 inches to receive the ends of the covering.

STRINGERS—of flatted pine timber, to form bearings for the top covering, are to be placed not more than 4 feet apart, checked so that the upper sides shall be of a like height as the check in the side timbers; they are to be fastened with rag-bolts three-fourths ($\frac{3}{4}$) of an inch diameter and 12 inches long, one at each end and crossing of a tie.

The interior of the superstructure must be filled, as the work progresses, with coarse material selected from the excavation, and care taken that it be well packed around and between the ties, as well as to have the top properly levelled.

TOP COVERING—to be of 3-inch pine plank, laid crosswise, 1 inch apart, and fastened at the ends and every crossing of a stringer with 7-inch pressed spikes.

MOORING POSTS—are to be placed 30 feet apart, on both sides of the entrance, of white oak timber 10 feet long 16 inches in diameter, properly dressed, covered on top with a cast iron cap-piece, and arranged in cases or boxes of hardwood or tamarac plank, bound with iron and secured to the timbers of the docking, or otherwise, as may be directed.

The sides of the superstructure, from the top to low-water line, must be hewn down neatly to lines corresponding to the position of the work, and everything done that is necessary to leave the whole in a finished and satisfactory condition.

The corners, for 25 feet each way, must be sheeted with 4-inch tamarac plank, extending from the top downwards to 4 feet under low-water line. Plank to be fastened with 9-inch pressed spikes, and further secured with straps 3 inches wide, by half an inch thick, of wrought iron, placed not more than 3 feet apart vertically. The straps are to be punched at every 12 inches, and the holes countersunk to receive the heads of the fastening bolts, which are to be three-fourths of an inch diameter and 10 inches long.

WHARVES.—At both ends, and along the river side of the basin, a continuous wharf 25 feet in width, is to be formed at the same height as the coping of the walls where they connect, and have a descent outwards of 6 inches or more, as may be directed; the horizontal sleepers of which may be of flatted cedar, 10 inches thick, placed not more than 3½ feet apart.

The sleepers to be anchored by means of tie rods, or otherwise, to cross sills 12 feet apart, placed at least 4 feet below the surface of the bank.

The spaces between the sleepers are to be filled with broken stone, well beaten down, and the covering is to consist of an approved quality of 3-inch pine plank, laid so as to break joint every three plank, and lengthwise, either laid close or ¾ of an inch apart, as may be directed; fastened with 7-inch pressed spikes, two at each end of a plank and one on alternate sides at each crossing of a sleeper.

Anchor bolts, passing down into the fourth course of masonry from the top, are to be placed 40 feet apart at the ends and sides of the basin.

Their upper ends are to be a little below the top of the coping, which is to be hollowed out to receive mooring hooks, that are to be fastened and arranged to the ends of the bolts in a similar manner as those on the north-west side of the present lower basin.

From the water-wheel, which works the swing bridge above the lock, a cast iron pipe, 18 inches in diameter, is to be laid and continued downwards, so as to discharge the water used for that purpose 4 feet below the surface of the present basin (No. 1).

This pipe must be laid as early as possible after the works are commenced.

After the spaces between the respective ranges of locks and basins have been carried to the proper height, the surface must be graded transversely, so as to form a double roadway with an inclination towards the centre. Between the head of the first lock and the basin, also from the basin to the foot of the second lock, the longitudinal grades are to be about 4 to 1.

The whole of this space is to be macadamized, except the centre, which is to be occupied by the water-table.

Macadamizing to be throughout 12 inches in depth, and may consist of granite boulders or good limestone, broken to such dimensions that none of the stone used for the lower 6 inches in depth shall exceed 3½ inch measured in any one direction; and for the upper 6 inches they are to be broken so that the largest stone in longest dimension can be passed through a ring of 2 inches diameter.

After the second course or layer of stone has been put on, the top must be blinded with coarse sand or fine gravel for an average depth of 3 inches, and the whole must then be compressed by means of a heavy roller drawn at least ten times over every part of the surface that has been macadamized.

The water-tables to be formed of a durable class of sound, well-shaped stones, from 8 to 10 inches in depth, pitched, laid close together, and properly bedded in well-pounded sand.

The upper surface of them to be concave 6 inches or more transversely, laid straight on the sides, and have a width of from 3 to 5 feet, as directed.

From the side of the first lock and basin outwards, the bank is to be graded to such a width and inclination as may be directed; and that part of it beyond the wharf, and at the upper end of the basin, also to the eastward of the second lock, as well as the new part of Mill Street, must be macadamized to a depth of 12 inches, with stone of a like class, broken and laid in a manner similar to that above described for the road between the two ranges of locks.

Where the new bank or roadway is higher than the adjoining harbor property, the outer edge of it is to be made with a slope of 3 horizontal to 1 vertical, the face of which must be formed of pitched stone not less than 18 inches in depth, well laid and pounded down to an uniform surface, and afterwards blinded with coarse sand.

At the foot of the slope a water-table is to be formed, if so directed.

The gates of the old locks, and the sluices of the waste weir are to be carefully removed by the contractor, and transported to such a place in the vicinity as may be directed, where they are to remain the property of the Department of Public Works.

At the place where the lower entrance is to be formed, about 150 feet of the existing pier work must be entirely removed, to admit of the new side piers being constructed, and forming a channel of the width and depth previously stated.

In doing this care must be taken not to injure the adjoining parts of the structure, and to make such arrangements that the new work can be connected with the old pier in a strong, substantial and satisfactory manner.

When proceeding with the works, the contractor must conduct his operations in such a manner as not to interrupt, impede, or in any way interfere with the navigation of the canal, or the towing of vessels between the harbor of Montreal and the basin above the second lock.

In the delivery of materials, as well as in every other respect, he will be subject to the canal regulations now in force, or such others as may be adopted or sanctioned by His Excellency the Governor-General in Council.

He must also construct and maintain during the progress of the works, at his own cost and expense, a temporary bridge in such a position as to accommodate, and sufficiently strong to admit of passing the heaviest kind of public traffic, and otherwise meeting the requirements of Mill Street, to the full satisfaction of the officer in charge.

As previously stated, the place where the works are situated is liable to be inundated for the greater part of the winter, consequently the whole must be several times pumped out, and as the material to be removed from the site of the outlet lock and basin has been chiefly formed from dredging, dumped on the natural bed of the river, there is every probability that considerable leakage will have to be contended with. The contractor must therefore provide sufficient pumping power to unwater the whole expeditiously when required, and to keep the different places as nearly as possible dry when the works are in progress. He must construct coffer dams wherever it may be necessary to keep out the river or other water, or to guard against leakage, springs or surface drainage.

The cost of all such dams, together with the expense of pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with the unwatering of the lock-pits, basin and all other portions of the works during their progress, and up to the full completion of the whole and the satisfactory removal of all coffer dams and other temporary works, must be embraced in the bulk sum stated in the tender for unwatering the works.

If the Department of Public Works considers it necessary to drive piles at any part or for the whole of the foundation of the outlet lock, piles of an approved class and dimensions must be provided and driven by the contractor in a satisfactory manner, and have their tops properly levelled to form an uniform bearing for the foundation or other timbers.

The lock gates, guard gate and swing bridge, as well as the machinery for working them, will form a separate contract; but all the masonry required is to be done by the contractor for the locks.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangement and general mode of construction; but detailed working drawings, arranged, modified and adapted to each lock, foundation, etc., etc., and for all such other parts of the structures as may be required, will be furnished as the works proceed.

MATERIAL, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for placing or preparing materials. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work as contemplated in this specification.

All materials must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described and the instructions of the engineer in charge.

The party whose tender may be accepted shall be subjected to all the clauses and conditions in regard to payments, retained percentage and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada, and to such other special conditions as the nature of these particular works may, in the opinion of the Minister of Public Works, seem to demand.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract with the Department of Public Works, and must be proceeded with in such a manner that the pits for both locks and seats for the basin walls shall be excavated to the full depth, and the foundation of all of them laid, on or before the 15th day of August, 1874; and at least 6 feet in height of the respective walls built and fully banked up on or before the 20th day of October, 1874, and flooded with water or otherwise protected from the action of the frost by the 10th day of November following; and the whole of the work embraced in the contract completed on or before the 20th day of November, 1875.

JOHN PAGE,
Chief Engineer of Public Works.

DEPARTMENT OF PUBLIC WORKS,
OTTAWA, 10th June, 1873.

APPENDIX No. 36.

LACHINE CANAL.

SPECIFICATION for the Construction of Wellington Basin, and the Enlargement and Deepening of Basin No. 2.

The present basin, known as No. 2, is to be enlarged by removing the triangular point of land lying north of the road between Wellington Street Bridge and the Waste Weir at Tate's Dock. This space, together with a channel connected with it, of such dimensions and in the position indicated on the general plan, will be sunk to a depth of 19 feet, and all other parts of the basin made 13 feet in depth. The new basin to be constructed, named Wellington Basin, is to be 19 feet in depth and 1,250 feet in length, with a clear space of 225 feet between the side or dock walls, and made so as to correspond with the lines represented on the plan and marked out on the ground.

Along the east and west sides and south end of the new basin, the banks are to be made up to the height of the dock walls, or 3 feet over canal surface, and for such widths as may be required for roads, warehouse lots, etc.

The material used for this purpose is to be taken from the excavation, and the balance, together with that from the enlargement and deepening of No. 2 Basin, must be hauled and spoiled in the bed of the river, immediately below the embankment, forming the west approach to Victoria Bridge, or at such other places as the Department of Public Works may authorize, without increasing the length of haul.

WELLINGTON BASIN—is to be excavated of sufficient length and width to admit of building the necessary dock walls, and leaving it the full dimensions above stated (1,250 ft. by 225 ft).

The bottom is to be trimmed to a fair surface at the level of 10 feet below the top of the lower mitre sill of Lock No. 3, and an allowance of one horizontal to one vertical will be made for slopes on both the sides and ends of the basin.

The dock walls are to be of masonry, laid in hydraulic cement mortar, on a foundation of timber and plank placed so that their upper side shall be on the same level as the bottom of the basin.

The seat for the walls must be excavated first, so that the excavation of the basin and making up of the banks can be proceeded with simultaneously with the building operations.

The timbers forming the foundations are to be of pine, 12 inches square, in lengths of from 30 to 50 feet, counterhewn, laid longitudinally in five continuous ranges, one corresponding with the front line, and another with the back line of the respective walls; the other three intermediate ranges being placed so as to leave the intervening spaces nearly equal; a timber is also to be placed at the rear line of each counterfort. They must all be laid so that no two joints on adjoining ranges shall be nearer than 6 feet of each other, and in all cases the timbers must rest uniformly on the bottom throughout their entire length.

All the spaces between them must be filled with the best description of puddle, well cut, rammed and pounded, or with concrete, as may be directed.

The top of the timbers when laid, if required, must be dubbed to an uniform surface to receive the covering, which is to consist of 3-inch pine plank, laid obliquely to close joints, and secured with 7-inch pressed spikes, two at each end, and one at every crossing of a timber.

DOCK WALLS—are to be built along the end and on both sides of the basin, and at the ends adjoining the entrance to it, 325 feet on the east side, and of a length to connect with Wellington Street Bridge abutments on the west side. They are to be 9 feet wide at bottom, with counterforts in rear, 6 feet long in line of wall and 3 feet projection, at intervals of 12 feet. The face of the wall to have a batter of one in twenty-four, and the back carried up plumb to within 5 feet of the top, where the counterforts will terminate, and the whole batter uniformly to the rear line of the coping.

The angles at the entrance to the basin are to be rounded off to a radius of 3 feet.

For 17 feet over the foundation, the face of the walls is to be of coursed work, the stones of which are to be scabbled and dressed so that they can be laid throughout in such a manner as not to exceed five-eighths ($\frac{5}{8}$) of an inch mortar joints. They are not to be less than 9 inches in height, but it is not necessary that a course should be continuous of the same height for a distance of more than 20 feet, provided the stones are checked where the course is broken, so as to admit of securing in all cases a bond of at least 12 inches.

The face of the stones must invariably be picked or scabbled to lines corresponding to the position they are to occupy in the work. They must be at least 20 inches and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet apart from centre to centre.

For the upper 4 feet in height, the face of the dock walls is to be of CUT STONE, neatly dressed and boucharded, made square, bevelled, circular or otherwise suited to the place they are to occupy, and are to be laid to $\frac{3}{16}$ of an inch, mortar bed and joints. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers; the latter to be at least 3 feet long in line of wall and not less than 2 and 3 feet depth of bed on the alternate courses. In each course must be headers of at least 2 feet length of face and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged, as nearly as possible, mid-way between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

BACKING—to consist generally of large well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below; no pinning will be permitted.

The edges of all thin, wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth of the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall.

COPING STONES—to be 4 feet wide on top, increasing in width downwards, corresponding to the frost batter in the rear and to the face batter of the walls. They must be at least 15 inches height of course, and not less then 4 feet long in line of wall.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

CONCRETE,—where used, must consist of an approved quality of stone broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

MORTAR—The whole masonry of the dock walls must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of an approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided

by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time; and the laying of stone be discontinued by the 10th day of October, each year during the period the works are in progress.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls, and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the walls to be 3 feet in width, carried up the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded and everything done to render the whole impervious to water. Puddle beds, where required at other places, are to be made in a similar way, and of such dimensions as may be directed.

SEWER.—At about 170 feet from the face of the east dock wall a brick-work egg-shaped sewer 3 x 4 feet, is to be built and placed so that at the north end it shall be 12 feet below the canal surface, and the bottom have such a declivity southwards as to intersect at a proper level the drain built by the corporation of Montreal along the line of St. Etienne Street.

It must be of hard-burned best class of sewer bricks, laid in hydraulic cement mortar, walls to be 13 inches thick, placed alternately header and stretcher in every course, and thoroughout built to patterns, and on centering, in a workmanlike and satisfactory manner.

The excavation made for its reception must, from the bottom upwards to where the top curve commences, be cut out as nearly as possible the shape of the walls; and care

must be taken to fill in and pound the earth uniformly on both sides as well as over the arch.

Shafts 12 inches square, and man-holes 2 feet square, of brickwork, connected with the sewer, are to be carried up at such places as may be required, capped with a perforated stone into which grating has been secured at the level to carry off the surface drainage.

The seats of the embankments for at least a width of 20 feet in rear of all the dock walls must be mucked, and all loose material, sods and other objectionable matter removed to the place where the surplus excavation is to be deposited.

The best material found in the basin excavation is to be used for making up the banks alongside of the dock walls, the roadways and adjoining warehouse lots. It must in all cases be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding one foot in depth at a time.

WHARVES—alongside of the dock walls are to be formed 36 feet in width, of 3-inch pine plank resting on sound flatted cedar timbers, laid parallel to the walls at a height to admit of the top covering being on the same level as the coping. The sleepers must be at least 10 inches thick, and not less than 25 feet in length, placed 3½ feet apart; spaces between them to be filled with broken stone well beaten down.

Plank to be of an approved quality, laid so as to break joints every three planks, and lengthwise, either laid close or ¾ of an inch apart, as may be directed, fastened with 7-inch pressed spikes, two at each end of a plank, and one on alternate sides at each crossing of a sleeper.

MOORING HEADS—of cast iron, placed 30 feet apart, are to be let into the coping and secured with anchor bolts passing down into the third or fourth course of masonry from the top. They are to be made of such dimensions and pattern, be fastened and secured in such a manner as the officer in charge may direct.

BASIN No. 2,—for the extent represented by the dotted red lines on plan, is to be enlarged and deepened to 10 feet below the lower mitre sill of Lock No. 3, and the sides of this deep-water channel are to be made with slopes of two horizontal to one vertical.

At all other places the basin is to be excavated or dredged to an uniform depth of 4 feet below the lower mitre sill of the third lock.

On the west or city side the deepening is to be commenced at 4 feet from the face of the dock wall, and thence slope or incline downwards at the rate of 1 foot for every 2 feet horizontally.

On the east or Mill Street side the deepening is not to approach nearer to the face of the dock walls than 6 feet, and the side inclination is to be 3 horizontal to 1 vertical.

The banks around the triangular point that at present projects into the basin shall not be removed before satisfactory arrangements have been made to prevent water from the canal passing over the ground to be occupied by the works, or in any way flooding the low land in the vicinity.

Parties tendering should clearly and distinctly understand that in proceeding with the works of deepening or enlarging the basin, the operations will not be allowed to interrupt, or in any way interfere with the navigation of the canal, or with the passage

of vessels into, or out of the basin. They should also bear in mind that the contractor will not be allowed, on any terms, or under any circumstances, to pass loaded mud scows out of or into the canal, through any of the locks.

All material excavated from the basin must be transported to the place where it is to be spoiled, or otherwise disposed of without passing through any of the locks, or in any way obstructing, delaying or interfering with the passage of vessels.

In all other respects the contractor will be subject to the canal regulations now in force, or such others as may be adopted and sanctioned by His Excellency the Governor General in Council.

The contractor must construct and maintain all dams wherever it may be necessary to place them, in order to keep out the canal, river or other water, and to guard against springs, leakage or surface drainage. The cost of all such dams, together with the expense of pumping, baling, removing snow and ice, and every contingency directly or indirectly connected with the unwatering of Wellington Basin, and for the construction of the dock walls, or for any other purpose required during the prosecution or for the completion of the works, must be embraced in the bulk sum stated in the tender for unwatering the works.

It is to be fully understood that the whole of the work to be done for the deepening and enlarging of No. 2 Basin will be measured, computed and paid for in the "solid."

For this purpose, before the works are commenced, levels will be taken of all that portion of the ground for the enlargement, and accurate soundings made (with reference to a fixed and permanent bench mark) at short distances apart along the whole length and width of the basin, and from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payments will be made.

The price tendered per cubic yard to embrace the cost of removing the material and depositing the whole of it in spoil bank at that place in the bed of the River St. Lawrence immediately below the west approach to the Victoria Bridge.

The material excavated from Wellington Basin and for the foundation of the dock walls and sewer, as well as mucking and clearing the seat of the banks, are also to be measured and paid for in the "solid." The price tendered for this work to include making up the adjoining banks in the manner described, and spoiling the balance in the bed of the river at the place above mentioned.

The work will be let in items, as stated in the printed forms of tender, which must be strictly adhered to, as no offer will be accepted unless in accordance therewith.

There are only to be two classes or denominations of excavation recognized, namely: "earth" and "rock"; the former to embrace all kinds of material found in the cuttings, except absolutely connected "quarry rock," and boulders containing more than one-third of a cubic yard. The prices tendered for these items to cover the entire cost of removing the materials, forming and finishing up embankments, depositing the material in spoil as stated, and completing everything connected with the excavation of the basins.

But as the price per cubic yard for each class of work will be an average of the the whole of that class, payments will only be made according to the comparative value of the work with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been

completed and executed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

Detailed working drawings will be furnished as the works proceed.

MATERIALS, SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for placing or preparing materials. He must also provide, furnish and deliver, at his own cost, all necessary materials, and procure all plant, excavators, dredges, tools, implements, derricks, machinery and labor, and everything necessary for the satisfactory execution and completion of the work as contemplated in this specification.

All materials must be of the best class of their respective kinds, and the price tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the work as herein described, and the instructions of the engineer in charge.

The party whose tender may by accepted shall be subject to all the clauses and conditions in regard to payments, retained percentage, and otherwise of the contracts generally entered into for the construction and execution of works under the Dominion of Canada, and to such other special conditions as may, in the opinion of the Minister of Public Works, be necessary.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract with the Department of Public Works, and must be proceeded with in such a manner that at least one-half of the work embraced in the contract shall be done by the 20th day of October, 1874; the dock masonry completed by the 20th day of October, 1875, and the whole work executed and finished in a satisfactory manner on or before the 1st day of December, 1875.

JOHN PAGE,

Chief Engineer of Public Works.

DEPARTMENT OF PUBLIC WORKS,

OTTAWA, 13th June, 1873.

APPENDIX No. 37.

LACHINE CANAL.

SPECIFICATION for the Superstructure of a Road Bridge to be constructed at Wellington Street, MONTREAL.

The bridge is to be placed at an angle of sixty-one degrees to the centre line of the canal and is to occupy the position indicated on the plan. It will extend over four waterways, on one of which, on each side, the bridge will be stationary, and the two centre openings or navigable channels will be spanned by a movable structure working on a turntable in the centre.

The swing or movable portion of the bridge will be built on the Howe Truss principle, the lower cords of which, as well as the floor members, are to be chiefly of iron —the upper cords, posts and braces to be of wood.

The girders for the stationary part of the bridge are to be of wrought iron beams trussed, and a railing is to be placed on each side of the structure, as represented on the exhibited.

These stationary parts of the structure will each be about 44½ feet in length and the movable parts will be 143 feet long, measured along its centre line. On the latter the width from centre to centre of the chords will be 18 feet and the height of the truss between the chords 5⅔ feet.

To provide for the skew, the truss on the up-stream side of one end and down-stream side of the other end of the movable part of the bridge will, in each case, be 10 feet longer than that on the respective opposite sides.

Swing Bridge.

Top Chords—to be 140½ feet long, formed of three thicknesses of the best quality of sound white oak plank thoroughly seasoned, each of which must be

11 inches by 4 inches when satisfactorily dressed, planed and squared, and in lengths varying from 16, 22, 27, 34, 39 to 45 feet. The three sections of each chord to be connected together by screw-bolts ½ inch diameter, having cast iron washers; two bolts to be placed at the centre of each panel of the truss. Joint keys 2½ inches wide and ¾ of an inch thick, of well seasoned white oak are to be let ⅜ of an inch into the chord pieces at the places where the connecting bolts are situated. There are invariably to be two joint keys directly opposite each other at the places mentioned, except where an end joining occurs in one of the outer chord pieces. The keys and their seats lengthwise of the chords must be wider above than below to enable them to be driven tightly together before bolting the pieces together. The chords are to be stop-chamfered at the panels of the trusses, have checks cut in them for the prism blocks and otherwise be made as represented. The top must be bevelled off to receive a zinc covering and a moulding is to be planted on it as shown on plan.

MAIN AND COUNTER BRACES—to be 9 inches wide and from 3½ to 4 inches and from 4 to 5 inches thick; end posts to be 12 x 6 inches, all of which are to be of the best quality of sound, well-seasoned white pine timber, except the main braces on each side of the suspension posts or pivot panels, which are to be of like dimensions, but of sound, well-seasoned white oak timber.

All the braces must be made of the shape and chamfered in the manner shown on drawing; the upper and lower ends of them must be made to fit accurately to the faces of the prism blocks.

Patterns are to be prepared under the supervision of the engineer, when such allowance as may be necessary for compression is to be made and the proper length of the braces determined, which, when framed, must, in all essential points, correspond accurately with the patterns.

When the trusses are put in place, each set or panel of braces is to be connected together at the centre by means of a screw-bolt one half-inch diameter, under both head and nut of which must be placed approved cast iron washers.

BOTTOM CHORDS—to be formed of two sections of channel iron each 8 inches deep and 2 inches wide, weighing about 18 lbs. per lineal foot.

The iron must be in lengths to extend over two or more panels and arranged so as to break joints in a satisfactory manner. At each joint there are to be two covering plates of wrought iron, each 15 inches long by 6½ inches wide, varying for the different places from ¼ to ½ and from a ½ to ¾ of an inch in thickness and similar plates are to be used at such other places as may be required. Cast iron distance pieces or ferrules are to be used, and eight bolts put in to secure each joint. The bolts to be from ⅞ to 1 inch diameter, according to the place they are to be used; they are to have nuts at both ends if so directed.

The different pieces of the channel bars forming the chords must respectively be of the exact length shown on the plan, and in every case they must be made perfectly square and finished at the ends so as to make fair and close butt joints. When the several pieces forming each section of the chords are in place, the two sections are to be bolted together as above described, and have the top side of them slotted out for the seats of the prism blocks. The spacing for the slots must be very carefully done, so that the blocks will fit in closely when in place and at the same time be accurately the distance apart shown on plan. As above stated, this portion of the work must be very carefully executed, as no allowance can be made for variation. It may here be stated that under the foot of the suspension posts the channel irons are to be double.

PRISM BLOCKS—to be of cast iron, 12 inches long, 9 inches wide and 4½ inches deep; on the lower side of the bottom ones, and upper side of the upper ones, ribs are to be cast for the purpose of keeping them in position both ways of the chords. The middle rib is to be 4 inches wide and half an inch deep on the bottom range, and a like width, but three-fourths of an inch deep, for those on the upper side. This rib should be cast large so that when properly fitted up it will be truly in the centre of the block.

The washers on the top chord to be cast double to receive both tie rods; they will be 15 inches long and 6 inches wide at bottom. The bottom washers are to be single. See details on enlarged drawing.

TIE RODS—to be from 1 inch to 1⅝ inch diameter, according to their position; they must be made of the best charcoal iron, and both ends of them must be sufficiently upset for the full length of the screw, so that when the thread is cut the bottom part of it shall have a diameter equal to that of other parts of the rod, and the nuts on both ends of them must in all cases have a depth of 1¼ times the outside diameter of the thread. Cast and wrought iron washers must be provided and used in connection with the tie rods, as represented on drawing.

TRANSVERSE FLOOR BEAMS—to be formed by means of two channel irons, 9 inches deep, 2½ inches wide and about 19 feet long, each section weighing not less than 20 lbs. per lineal foot. They are to be bolted together, and kept 2¼ inches apart by the chairs or ferrules for the longitudinal beams.

The two end beams, in each case, are to be formed to suit the skew of the bridge—the lengths must be made and the shaping executed as shewn on plan.

TURNTABLE GIRDERS.—For the purpose of carrying or supporting the bridge when in motion, two cross girders formed by large I beams, trussed, rivetted bottom flanges, and cross rivetted connections to form bearings for the turntable paths, must be provided and fitted up.

The dimensions and form of the iron required, as well as the manner of connection with the truss and other particulars of this portion of the work, can be seen on an examination of the enlarged detailed drawing.

FLOOR BEAMS—to consist of four (4) ranges of wrought iron I beams, placed longitudinally, eight pieces of which will vary from 14 feet 7 inches to 33 feet 1 inch in length; four pieces will be 27 feet 5½ inches long, and twelve pieces 22 feet 5½ inches in length; all of them to be 7 inches deep, and weigh about 20 lbs. per lineal foot. They are to be placed so as to join on the transverse beams and sit in chairs made to receive them, and be fastened in place by means of split-keys. The whole to be arranged so that the joints in adjoining beams shall not, if possible, be opposite each other.

There are also to be five (5) ranges of timber beams, varying from 6 inches by 7 inches to 6 inches by 9 inches, one range to be placed in each of the spaces between the iron beams, and one between them and the chords. They are to be secured to the cross beams by bolts and cast iron washers, as shown on plan. The upper side of these beams must be trimmed off, crowning, in such a manner that the covering of the bridge, when laid, shall be about 2 inches higher in the middle than at the sides.

SUSPENSION FRAME—to be 25 feet in height over the floor of the structure. The posts are to be supported longitudinally by strut braces and transversely by perforated cast iron bridging and tie rods. The posts are to be formed of

three thicknesses of sound, well-seasoned white oak plank, properly dressed to the dimensions, and shaped in every respect as represented.

Before the different sections of the posts are fastened together, those sides of the planks forming the joints must receive two coats of the best white lead and linseed oil. The manner of bolting them and mode of attachment to the top chords, also their connection with the step-pieces at the bottom chords, etc., will be seen on the enlarged drawing.

The strut braces are to be framed about one-eighth of an inch longer than indicated, so as to insure them taking a firm bearing.

On the top of each post a cast iron saddle will be placed for the wire suspension-cables; also a cast iron seat for the finial on top. The latter to be of wood, built up of pieces of not more than $2\frac{1}{2}$ inches in thickness before they are turned. When finished and in place, they are to be secured by set screws to the cast iron seats. For the manner of securing the bridging, saddles and seats of posts, see plan.

CABLES.—On each side there are to be two cables, seven-eighths and 1 inch diameter, respectively. They are to be formed of the best steel wire. Where the tightening rods are attached to them, there is to be a threaded splice not less than 24 inches long; before the splice is made cross heads are to be put in for a turn-buckle attachment.

The iron used for the tightening rods must be of the best quality, capable of standing a tensile strain of 60,000 lbs. to the square inch before breaking, turn-buckles to be of approved shape and dimensions, with right and left-handed screws, and must be arranged so that when geared up in place, those on the different cables will work in opposite directions.

TURNTABLE—equipment to embrace amongst its different parts a cast iron centre, two steel tracks, fourteen cast iron coned rollers, with spacing rings, radial rods, two safety rollers, etc., etc.

The centre casting to be 24 inches diameter at base, and have a barrel 10 inches diameter, part of which is to be turned to the dimensions shown, to receive a wrought iron collar. This casting is to be secured by a fox-wedged bolt $1\frac{1}{2}$ inches diameter, let 6 inches into the pivot-stone.

The wrought iron collar to be turned, neatly bored out to fit the barrel, and properly tapped to receive the ends of the radial rods. Betwen the offset on the centre casting and the collar, a brass liner ring, $\frac{1}{4}$ of an inch thick, will be interposed. There are to be, as above stated, 14 cast iron rollers used for pivoting the bridge, each of them 6 inches long, and 10 inches diameter at the largest end; they must be accurately turned to the conical shape required for perfect rolling motion, all of them to be alike or exact duplicates of each other.

The roller paths or tracks are to be of cast steel; they must have their faces turned up to the inclination and be finished to the dimensions represented. The lower path to sit in a circular check cut for it in the pivot-stone of the bridge, and the upper path is to be secured to the girders by four knees bolted to gusset plates which carry the ends of the safety roller axle and have bolts tapped into back of the path.

To prevent movement, 4 stud bolts, each $1\frac{1}{2}$ inches in diameter, are also to be tapped into the back of the path and let into the girders one inch and a half. The spacing ring to be $6\frac{1}{2}$ feet diameter (inside) made of bar iron 3 inches wide and 1 inch thick; the holes

for the radial rods must be spaced equally and bored truly to the radial lines, radial rods to be 1 inch diameter with heads forged on one end and the other end screwed for entering the wrought iron collar and adjusting the rollers. Between the ends of rollers and inside of the spacing ring, a turned-up washer must be fitted on each rod, the washers to be of brass or iron, as may be subsequently determined.

SAFETY ROLLERS—to be of cast iron 27 inches diameter, the seat for the axle to be $3\frac{1}{2}$ inches diameter, the wheel to be secured to the axle by set screws and the tread turned up to the round shown on drawing. The axles to be of the best Thorneycroft iron, upset to $3\frac{1}{2}$ inches at wheel seat and outer end. The wheel seat and journals are to be finished to the dimensions given; the axle boxes are to be truly bored out for journals and secured to gusset plate on the turntable girder at inner end and to wrought iron plates bolted to the cross beams at outer ends. Double tie rods for each wheel must be provided and secured as shown. The path for safety rollers to be of cast iron, of the form and length shown on drawing. It is to be secured by fox-wedged bolts to the top of the pier.

WORKING GEAR—to consist of a rack and pinion worked from the floor of the bridge. The rack will be in three pieces, each about $4\frac{1}{6}$ feet long on the pitch line; they will be secured to the top of the pier by fox-wedged bolts, two in each piece. The teeth of both rack and pinion to have 2-inch pitch and must be cleanly cast, all the furring must be dressed off and each casting be perfectly sound and free from holes. The pinion shaft will be secured to a seat and collar fastened to the floor beams and safety roller plate. On the top of the spindle a seat of cast iron, strengthened by a wrought iron hoop, will be secured for the end of the capstan. It will be flush with the floor when finished; and for protecting the spindle and gear from dirt, a wrought iron dished plate $\frac{1}{2}$ inch thick, sitting in a wrought iron lining ring, the latter to be let into the floor its whole depth and fastened securely. For the arrangement, dimensions and mode of securing the gearing, see enlarged detailed drawing.

LOCKING GEAR.—For the purpose of securing the bridge in place when either open or shut, an automatic gear, of which two locks form a part, will be secured on the outside of the bottom chord at the oblique corners of the bridge. This gear will be worked by a lever placed near the middle of the structure. In order to operate the locks, a shaft and quadrants will be required and the connection completed by two strands of railway signal iron. For further details, see plan.

CAMS.—For the purpose of supporting the bridge when in position for traffic, three cams will be attached to the under side of each truss, one in the middle and one at each end. Each cam must have the steps and brackets placed and secured both to the truss and piers as shown or as may be directed. These castings must be made of tough iron equal in quality to the best used for railway car wheels, and when cast must be perfectly sound.

FLOOR—to be formed of two courses of plank—the lower one to be pine plank of good quality, 2 inches thick, in widths of not less than 5 inches nor more than 7 inches, laid transversely either one inch or three inches apart, as may be subsequently determined, and fastened with a 5-inch pressed spike at every crossing of a timber. The upper floor to be of good, sound, well-seasoned white oak plank 2 inches thick, laid longitudinally and fastened with 5-inch pressed spikes driven slightly oblique, $2\frac{1}{2}$ feet apart, the plank not to be less than 6 inches nor more than 8 inches in width and must break joints every third plank at least three feet.

GUARD TIMBERS—of white oak 6 x 6 inches to be placed on both sides of roadway, the inner top edges of which are to be chamfered and the whole

fastened over the top of the lower course of planking with screw-bolts half an inch diameter passing down through the outer floor timbers. The heads of the nuts must be boxed into the upper side of the guard timbers, and the nuts have cast iron washers. Two bolts to be placed in each panel lengthwise of the bridge.

Alongside of the guard timbers, on both sides of the bridge, at places about 11 feet apart, down-pipes are to be put in to carry off the surface water. They are to be of wrought-iron 3 inches diameter and 12 inches long, screwed up through both thicknesses of the flooring plank and left flush with the upper side of the second course.

The top of each of the upper chords, after it has been prepared and mouldings planted upon it, is to be covered with zinc, each piece of which must be fully 5½ feet in length and wide enough to extend over and be properly fastened to the face of the mouldings.

Stationary Bridges.

Over the two side channels, stationary bridges are to be built, each of them to be formed by means of three trussed girders placed about 8 feet apart, and at a height to act as beams for carrying the floor planking at the place where they are situated, in connection with the timbers put in for that purpose. For sustaining the longitudinal floor timbers wrought iron needle beams are to be placed under the top beams of the truss and be bolted or riveted up to them, as may be required; these needle beams are to be placed about 9½ feet apart, and extended outwards to form a base for the stay-brackets of the hand-rail.

Trusses—to be formed by beams, posts and tie-bars; they will be 38 feet long, 3 feet 4½ inches and 3 feet 6½ inches deep at centre of post, for the middle and outer girders, respectively. In each case the beam will be made up of two sections of channel bars 9 inches deep, placed 3 inches apart to receive the tie bars. Each beam to be made up of four pieces joined together at the posts, the side plates of the latter to form the cover plates for the joints. The posts to be five-eighths-inch boiler plate and angle iron. Tie bars to be of wrought iron varying from 4 inches by ½ inch to 7 inches by 1 inch, eye bolts to be from 2 inches to 3 inches diameter. For the particular form and dimensions of the respective pieces, as well as for the riveting, see plan.

Needle Beams—to be formed of two sections of channel iron, each 7 inches deep and 2¼ inches wide, fastened together 2¼ inches apart by means of screw-bolts ½ inch diameter, and inside ferrules. Two of these beams will be about 28 feet long, and two about 14 feet, for each span.

Floor Timbers—to be of pine, varying from 6 inches by 8½ inches to 6 inches by 11 inches. There are to be six ranges over each span; where they connect, the ends are to be half checked 12 inches and butted. The timbers are to be fastened to the needle beams at every crossing with bolts ⅝ inch diameter, and suitable cast iron washers are to be put under the nuts. After the timbers are in place, the upper sides of them are to be trimmed in such a manner as to give a proper crowning for the floor.

Floor.—The lower course to be of pine plank 2½ inches thick, and in widths of not more than 8 inches, laid transversely from one to three inches apart, and fastened to the bearing timbers by pressed spike, five inches long. The upper tier of plank to be seasoned white oak, two inches thick, laid longitudinally, and fastened with 5-inch pressed spikes. It will extend 8½ feet on each side of the centre line of the bridge. The lower tier of plank will extend out under the lower rail of the balustrade, and finish by a moulding of zinc.

BALUSTRADE.—On each side of the stationary portions of the structure, a balustrade is to be formed, finishing with the parapet walls at the approaches, and the parapet on the bridge seat piers. It will have moulded top and bottom rails, and cast iron open panels. The bottom rails are to be secured to, and carried on, plates of wrought iron and angle pieces attached to the needle beams. The rails are to be of sound and well-seasoned white oak timber, dressed and neatly finished, to correspond with the members of the stone work at each end. For further details of the mode of construction and attachment to the bridge, as well as for the stay-brackets, etc., see drawing.

PAINTING.—All the channel bar beams, wrought and cast iron work connected with them, must receive one coat of red oxide paint before they are put together, and the wood work a priming coat of white lead and linseed oil. When the bridge works are in place, the whole (floor excepted) must receive two full coats of the best white lead and linseed oil paint, in such colors as may be directed ; sufficient time must be given for each coat of paint to harden properly before the second or third coat is put on.

SCAFFOLDING.—The bridge will have to be erected in the position it is to occupy when used for public travel. To accomplish this, suitable scaffolding of trestle work must be provided and built by the contractor across the canal, at his own cost and expense. It must be made sufficiently strong to carry the structure, and be raised to the height of the under side of the upper chords and throughout be well secured by braces, both transversely and longitudinally. If the chords are put together elsewhere than on the scaffolding, they must not be lifted to their position in lengths of more than 40 feet at a time. Arrangements must be made to urge forward the works in such a manner that the scaffolding can be fully removed from the canal by the contractor on or before the 25th day of April next.

The drilling of holes for all those parts of the work which require to be attached to the masonry must be done by and at the expense of the contractor, and should, therefore, be included in the prices tendered for iron work.

PATTERNS—for the iron work will, for the most part, be furnished to the contractors ; but some of them will have to be slightly altered, and for some parts of the work new patterns will require to be made by and at the expense of the contractor.

On the completion of the bridge, all the patterns used for castings or otherwise, in connection with the work, whether they were furnished to the contractor, or made by him, must be put into good order, packed in suitable cases, and handed over to the Department of Public Works before the final estimate is paid. All the cost of alterations to old patterns, and the expense of making new ones, must be borne by the contractor, the outlay on which must be included in the prices tendered for the works.

All the materials used in the structure, whether wrought iron, cast iron, oak or pine timber, or whatever is required, must be of the best quality of their respective kinds, prepared, worked, finished and fitted up as described in the foregoing specification, and represented in the plans exhibited.

DETAILED PLANS.—The plans exhibited are intended to show the contemplated arrangements and general mode of construction, but for the full understanding of the design, when patterns are not furnished, further detailed plans will be supplied for such parts of the structure as may be considered necessary as the works proceed.

It is, however, to be clearly and distinctly understood, that in case any details of the work required are not shown on the plans or herein described, the work necessary to

carry out the design must, nevertheless, be done by the contractor, at the rates stated in the tender for similar or corresponding parts of the works.

SERVICE GROUND, ETC.—The contractor must provide, at his own cost and expense, all the service ground that may be required for the preparing or placing of materials. All the rolled iron for chords, beams, etc., also all the timber required for the bridge, must be provided and ready for inspection on or before the 4th day of March next.

Contractors should bear in mind that no advances or payment will be made on materials until they are in the works, or on canal property in the vicinity of where the bridge is to be built.

The works must be conducted in such a manner as to satisfy the Department of Public Works that the whole can be completed, and the bridge fully ready for public traffic, on or before the 28th day of April next, 1879.

JOHN PAGE,
Chief Engineer of Public Works

OTTAWA, 30th January, 1879.

BRIDGE over the head of the second locks above Montreal Harbor, or Mill Street crossing of the LACHINE CANAL.

The bridge will be 154 feet in length on the centre line of the roadway, and will extend over the upper entrance to both the new and old locks. It will be on the "Howe Truss" principle, 18 feet wide between the centre line of each truss. In the middle it will be carried on a turntable, which will serve for pivoting the bridge, and be in every respect similar to the one described in the preceding specification for Wellington Street Bridge.

The general arrangement of the structure in all its parts will be the same as shown and described for Wellington Street Bridge, except that the truss will be 6½ feet high between the chords, and the latter 12 inches by 13½ inches formed of three thicknesses of sound, well-seasoned white oak plank; the main braces are to be heavier, but the panels will have the same spread.

All the patterns used for the castings, etc., of Wellington Street Bridge can be used for those required for the bridge above the entrances to the second locks, except those for

the prism blocks, the double washers for the tie-rods on the top cords, and brackets for the cams. For these three different items of work new patterns will be required.

With the exceptions above stated, the foregoing specification and details for the movable or swinging part of Wellington Street Bridge is in every respect applicable to the bridge to be built above the entrance to the second locks, leading to Mill Street, and for which tenders are now also invited.

It may further be stated that the time fixed for the materials to be furnished (4th March next); the complete removal of all scaffolding by the 25th April; the condition on which advances or progress payments will be made, and the time fixed for the completion of the work (28th day of April next, 1879), as well as all the other conditions stated in the Wellington Street Bridge specification, are to be clearly and distinctly understood as applicable and, in every respect, as binding on the contractor as if they had been prepared and made specially for the execution of the work on and for the bridge to be built above the entrance to the second locks, or Mill Street crossing of the canal.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 30th January, 1879.

APPENDIX No. 38.

LACHINE CANAL.

SPECIFICATION of the Work to be done on SECTION No. THREE of the ENLARGEMENT.

This section extends from near the upper side of Wellington Basin to Station No. 50, about 700 feet above St. Gabriel Lock, and is a little over three-quarters of a mile in length, the respective boundaries of which may be seen marked out prominently on the ground. The works upon it consist chiefly in the enlargement of the channel to a mean width of 200 feet, and to an uniform depth of 13 feet below the assumed water line; building piers and abutments for Wellington Street Swing Bridge; the construction of a lift lock, regulating wier, raceway and bridge abutments; taking down the upper thirteen feet or more of the third lock and building it again, using new face stone throughout; securing the lower part of the north wall, and forming a temporary regulating weir and raceway on the south-east side of the canal, etc., etc.

The water level of the different reaches is to be kept at the same height as at present, and the foundation of all permanent structures, such as the lock, weir and dock walls, bridge abutments, etc., are to be placed sufficiently low to afford a depth of water suited to 14 feet on the mitre sills of the lock.

At the lower end of the section the channel will be widened on the south side, and be continued upward on such a line that, opposite the St. Gabriel Basin, the cutting for the enlargement shall be wholly on the north side of the canal; thence upward to the end of the section the increased width will be taken off that side.

The side lines of the channel and the position of the respective structures will, for the most part, correspond with the lines shown in *red* on the general plan exhibited. The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined; also of altering the position of any or all of the structures one hundred feet, either to the right or left, or of placing any or all of them two hundred feet

either upward or downward from that indicated on the plan, or in such other position as may be considered the most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

Part of the material excavated from the channel and from the foundations of the side walls, bridge piers and abutments can be deposited on that portion of the canal property bounded on the east by Wellington Street, on the south by St. Patrick Street, and on the north by what is called Canal Street. This lot of ground is barely two acres area, but the spoil bank formed upon it can be carried up to the height of 12 feet or more over the level of the canal banks and adjoining streets, by keeping at such a distance from the streets and roads as not to interfere in any way with the public travel.

The Government property on the north side of the canal, east of St. Gabriel Lock, and between the latter place and the basins recently formed in that vicinity, is also to be used for "spoiling" material taken from the excavation of the channel, foundation of side walls, as well as for that taken from the pits of the lock, regulating weir and race-way. The western part of this land is, however, to be reserved for service ground for stone, timber, etc., required for lock, regulating weir, etc.

When spoiling the excavated material at this place, the rear part of the ground or that adjoining Ottawa Street is to be made up first, and the arrangements must be such that the bank shall be carried up throughout to an uniform height of 12 feet over the surface water level of the canal.

The spaces contemplated to be at a future time occupied by basins are not to be used for spoil ground until after the adjoining parts of the land shall have been made up to the height above stated.

It will be observed from the position of the works that a large proportion of the widening and deepening can be done by machinery during the summer months, without in any way interfering with navigation. Contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be prepared to move, haul, transport and elevate the material in such a manner as will enable it to be expeditiously conveyed to and deposited at the places and in the manner above mentioned.

Before the banks in the vicinity of the proposed basins are formed, especially at the north end of them, adjoining Ottawa Street, all sods, turf, muck and loose earth must be removed for a space of 20 feet in width on each side, and for such a depth as may be required to secure a water-tight connection with the bank to be formed over the seat thus prepared.

If any of the adjoining proprietors are desirous of having their land raised to such an extent as would be likely to form more advantageous spoil ground than that above mentioned, the contractors, on receiving the sanction of the Department of Public Works, may use part of the excavated material for that purpose.

Where the present banks of the canal or any portion of them are cut away by the widening, and where another bank has to be formed either in part or as a whole, especially if the ground is below water line, the surface must be removed for such a depth and width as may be directed, and the new bank be formed of the best description of material that can be obtained in the vicinity, put on in layers in the manner subsequently described.

In all cases care must be taken to place the best, most solid and water-tight earth in that part of the bank adjoining the canal, and to place all coarse materials, or such as are permeable to water, on the outer side, or, if required, remove them to the nearest spoil bank.

The bottom of the channel is to be made of an uniform depth of 13 feet below water line, and the foundation for the side or dock walls is to be sunk 2½ feet lower. The seat for the walls, however, is not to be excavated to within ten inches of the bottom until after the canal has been emptied, when it must be sunk to the depth above stated, and either trimmed off level throughout or made with a descent toward the rear of about two inches to the foot, as may be directed.

An allowance of one-half horizontal to one vertical will be made in the excavation for a slope in the rear of the side walls. In embankments the side slopes are to be made two horizontal to one vertical, or to such other angle as circumstances may require.

The contractor, when proceeding with the works, must invariably be guided by the levels given for bottom of cuttings, height and grade of banks, and lines marked out by the officer in charge.

Embankments must be formed to the angle required, and throughout be made uniform and neatly trimmed, so as to present a fair outline corresponding to the places where they are situated.

The material excavated from the lock pit, weir pit and raceway, must be hauled to and disposed of, on the spoil ground, previously mentioned as near the basins recently formed on the north side of the canal.

To effect this object, the contractor must construct and work, at his own expense and risk, a floating bridge or other movable structure, across the tail race from the mills, which is also a navigable channel that must be kept open for the passage of vessels.

Part of the material to be removed at the upper end and below the lock must be reserved for the purpose of making up the embankments in rear of the lock walls, weir and raceway walls, which, in like manner as at all places where a water-tight bank is required, must be hauled on in carts or wagons and laid on in layers not exceeding nine inches in depth at a time; and if considered necessary by the officer in charge, water must be thrown over each layer to assist in consolidating the bank.

The works will be let in items, as shown on the printed forms of tender, which will be strictly adhered to and no offer considered unless in strict accordance with the form.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock," the former to embrace all kinds of material found in widening and deepening the channel, except absolutely connected "quarry rock" and boulders containing one-third of a cubic yard and upwards. The prices tendered for these items to cover the entire cost of removing and placing the material in spoil bank, as herein described, forming and grading towing path and finishing up embankments in rear of dock or side walls in rear of lock, weir and raceway walls and wherever required on the section, in a workmanlike and satisfactory manner and agreeably to the design contemplated.

PUDDLE.—When necessary to guard against leakage in any of the banks, a puddle wall must be carried up at the same time as the bank is formed. It must be made of the best description of material for the purpose that can be obtained on the

section, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form puddle walls impervious to water.

About 2½ acres of the ground below the lock, on the north side of the canal, may be used by the contractors as service ground for depositing materials for the work, and a small piece of land above the lock, on what is called "The Island," may, after the necessary arrangements have been made, be used for a like purpose, but all other service ground must be provided by the contractor, at his own cost and expense.

It is to be clearly and distinctly understood that the whole of the work to be done for the deepening and enlarging of the canal on this section (No. 3), will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all that portion of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks), at short distances apart along the whole length and breadth of the work. A duplicate copy of the cross sections, made from these levels and soundings, is to remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from these, together with levels and soundings taken after the whole have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

Lock—to be 270 feet in length between the gate quoins, 45 feet in width between the side walls at bottom ; it will be placed on the north side of the present lock, and be parallel to it, and so situated that the longitudinal centre line through the respective structures will be 78 feet apart, and the transverse range of the upper gate quoins will be about 30 feet lower, or to the east of those in the old lock ; hence the lower quoins of the latter will be 100 feet west of those in the new structure.

A retaining wall, about 115 feet in length, must therefore be built in continuation, eastward, of the north wall of the present lock, which, at its lower end, will be connected with the lower south wing walls of the new lock.

Arrangements have also been made for a road crossing, by the extension of the upper wing walls to form the seat and bearings for a swing bridge.

At the lower end, a retaining wall 290 feet long, will be built, on a line in continuation of the north wall of the new lock, for the purpose of giving additional security to the tail race from the regulating weir, and forming a place where vessels can make fast to, when necessary.

The walls of the old lock, being in a ruinous condition, are to be taken down to fully two feet below the surface of the lower reach, or to such other depth as may be required ; and the walls are again to be built up with an entirely new and better kind of face stone.

The walls above mentioned, with the exception of those directly connected with the present navigation, are all to be commenced at a depth that can be adapted to vessels drawing 14 feet water passing through the canal ; otherwise the bottom and mitre sills of the lock, as well as the retaining and bridge seat walls are, respectively, to be *five feet lower* than those at present in use.

The faces of the several walls above mentioned are to be of the best description of properly-dressed gray limestone, backed up with large-sized flat-bedded stones of an

approved kind, laid throughout in hydraulic cement mortar, and placed on a foundation of timber and plank, prepared and arranged as herein described.

Contractors will observe that, before the foundation pit for the lock can be excavated to the proper depth, or laid dry, the channel leading to the present regulating weir must be closed, and that a dam must also be made at the lower end of the pit to keep out the water of the reach below.

The channel alluded to cannot, however, be closed until the means of passing a considerable volume of what is called the surplus water, have been provided. This, it is proposed to do by forming a temporary weir and raceway on the south side of the canal, at the place and in the manner subsequently described.

It should also be borne in mind that the leaky and defective state of the present lock renders it indispensable that at least the upper 13 feet of both walls should be taken down, new walls built, the lower part of the north wall secured, and the retaining wall below the present lock constructed before the dam at the lower end of the pit can serve any good purpose, or the temporary raceway on the south side be formed.

The works above mentioned having been completed as described in the latter part of this specification, the excavation of the lower part of the lock pit can then be proceeded with in the usual manner. It is to be made of suitable dimensions to admit the side and wing walls, and to correspond with the lines marked out by the officer in charge. Great care must, however, be taken not to disturb the narrow bank between the present lock and the pit. On this, the south side, a slope of one-half horizontal to one vertical will be allowed, and on the north side and ends an allowance of one to one will, in each case, be made for the slope.

The bottom must be made smooth and level at the proper height to afford throughout an uniform bearing for the foundation timbers, which are to be laid and covered with three-inch pine plank, to form a protection to the bottom, and a bearing surface for the side.

FOUNDATION TIMBERS—to be of pine 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up the distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill and at the lower end of the lock, and must rest uniformly throughout their entire length on the bottom and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; or, if directed, the spaces at the ends of the timbers must be made up with concrete; their tops must be dubbed to an uniform surface to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle or concrete as may be required.

MITRE SILL PLATFORM—to be 14 feet in width, made up of timbers 12 inches square and of a length to reach from rear to rear of walls, all of which must be counterhewn and well jointed with a plane so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts (1½ inches in diameter) passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, ETC.—Five or more trenches are to be cut across the foundation for the reception of sheet piles, namely: One at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed 2½ feet in width. One side of each trench must be cut plumb and smooth so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best material for that purpose which can be obtained within one mile of the work, and must be cut, mixed, prepared and laid as directed by the officer in charge. Ranges of sheet piles are also to be placed in the foundation of the chamber if so directed.

SHEET PILES—to be 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first, 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails 9 inches long and 1½ inches diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid; the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches, checked 3 inches into the platform timbers, and are to be

tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep is to be cut in the lower edge of the mitre sills to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas well saturated in boiling tar is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½") diameter, have upset heads, and be well ragged at the point.

MASONRY.—The lock is to be 8 feet 8 inches lift, and the side walls carried up to 2 feet over the surface water level of the upper reach, or to the height of 25 feet 10 inches over the floor.

The chamber and recess walls are to be 9½ feet wide at the bottom, with counterforts in rear 6 feet long in line of wall and 3 feet projection, and placed not more than 12 feet apart. The recesses for the gates are to be made 2 feet 8 inches deep at top.

The face of the chamber and wings is, throughout, to have a batter of *one* in *twenty-four*; but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the lock must be of approved, sound and durable stones; those forming the face work must be of the best class of gray limestone, free from drys, seams or other defects, and must be at least equal, in every respect, to the best of the stones used in the present guard lock at Lachine.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height: the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping, but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stone of equal height.

From the lower end of the lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths of an inch.

CUT STONES—to be neatly dressed and boucharded; made square, bevelled or otherwise suited to the positions they are to occupy in the work. The arris s must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than two and three feet depth of bed on the alternate courses. In each course must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than eleven (11′) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible mid-way between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least 1½ times their height and the headers 2¼ times their height; and in all cases the tail of a header must have a width of two-thirds (⅔) the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least 4½ feet face and 5½ feet depth of bed, the latter 5½ feet face and 4½ feet bed in the top courses, increasing in dimensions downwards at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also 4½ by 5½ feet and 5½ by 4½ feet, laid alternately out-bond and in-bond, bevelled as shewn on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain wells in the position indicated on the plan; each well will be two feet square inside, and the man-holes from them to the front of the lock walls are to be made at the angles and widths to permit the play of the chains and of such height as the engineer may direct.

The sills and lintels to be of stone sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

CHECKS.—For the reception of stop-water timbers, two checks are to be formed in the face of the wings at both ends of the lock; they are to be arranged as shown on plan, be 2 feet apart, 12 inches wide and 6 inches deep at the top, and made plumb in the rear.

COURSED WORK,—for the face of the chamber walls, may be 9 inches high and upwards, but a course once commenced must be continued the same height throughout, and in no cases will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth

of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone when in place shall not exceed three-eighths of an inch.

BACKING—to be of an approved class of large well-shaped stones not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick, but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall. The black limestone used for ordinary building purposes in Montreal will not be allowed in the work.

COPING STONES—of the chamber, recesses and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least 6½ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, of 1½-inch iron, to be inserted in every joint 15 inches back from the face and six inches from the top.

The descent from the coping of the lock to that of the retaining wall below it, on the west side, is to be made by means of a range of steps 4 feet in width, cut out of the solid; the rise of each not to exceed 9 inches and the treads to have an uniform width of 12 inches. They are to be arranged, placed and secured in like manner as those at the lower end on the east side of the second lock.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach unconnected with the side walls of the lock; it will be of coursed masonry 7 feet wide at bottom, plumb in the rear and on the lower side, battered to a width of 5 feet at the top and then covered with large flat-bedded, scabbled, and well jointed coping stones.

MORTAR.—The whole masonry of the locks and other structures to be described must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about $1\frac{1}{2}$ of clean, sharp sand to one of cement and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

BRIDGE SEAT.—To form bearings for a swing-bridge, walls are to extend upward, in continuation of those of the lock, as represented on general plan. They are to be built upon a foundation of timber and plank, the top of which will be at least one foot below the bottom of the upper reach.

The timbers are to be of pine, 12 inches square, counterhewn, and laid longitudinally in five continuous ranges, about 9 inches apart, in such a manner as to rest uniformly on the bottom throughout their entire length, and so that no two joints on adjoining ranges shall be nearer than 6 feet to each other. The spaces between them must be well filled with concrete, or otherwise, as may be directed. The top of the timbers, when laid, must be dubbed to an uniform surface to receive the covering, which is to consist of 3-inch pine plank, laid obliquely to close joints, and be secured with 7-inch pressed spikes.

The walls are to be 8 feet thick at bottom, with a face batter of one in twenty-four, the back to be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping.

They are to be of a like class of masonry, and laid in hydraulic cement mortar throughout, as described for the chamber walls of the lock. The upper end of the south wall is to be extended and curved so as to connect with the north side wall above the old lock, and the whole carried out, recessed, curved and otherwise adapted for the toe, as well as for the turntable on which the bridge is to move, as represented on a detailed plan to be furnished.

The foundation for that part of the seat for the turntable south of the side wall is to be laid at 8 feet below the top of the lock coping, and must be formed either of timber and plank or a stratum of concrete, as may be directed.

The coping stones are to be at least 15 inches in depth; on the side walls they are to be 4 feet in width on top, and those on the turntable pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers. They must be full bedded throughout, and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top must have a fair surface, neatly boucharded and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed; the space between it and the outer range of coping must be filled in with stone the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

CENTRE RETAINING WALL.—The seat for the wall below the present lock and opposite the lower recess of the new structure is to be sunk to an uniform depth of 16 feet below the surface of the lower reach, where a foundation of timber and plank is to be laid in like manner as described for the side walls above the lock, except that the timbers are to be laid 13½ inches apart, and that provision is to be made for carrying counterforts in the rear by placing two sill pieces under each to receive the planking.

The wall is to be 9½ feet thick at bottom, with counterforts in rear 6 feet long in line of wall and 3 feet projection, and placed not more than 12 feet apart; it is to have a batter of *one* in *twenty-four* on the face, and the back is to be carried up plumb to within 5 feet of the top, where the counterforts are to terminate and a continuous, regular, inclined, smooth frost batter formed up to the top rear line of coping.

The coping to be 4 feet wide on top, and in all other respects the materials used in the wall must be of like dimensions and of a similar class; and the workmanship throughout to be executed in like manner as described for the cut stone masonry portion of the lock.

Where the wall connects with the lower part of that of the present lock, the stones of the new work are to be bonded into those of the old, or such other course adopted as circumstances may require, and as may be directed when the building operations are in progress.

At the lower end, the wall is to be made circular, and connected with the lower wing of the new lock, as indicated on plan.

NORTH RETAINING WALL,—below and in continuation of the side wall of the new lock, is to be 8 feet thick at bottom, with counterforts 5 feet long and 3 feet projection, placed not more than 15 feet apart; on the face it is to have a batter of *one* in *twenty-four*, and the back is to be carried up plumb to within 5 feet of the top, where the counterforts, as in other cases, terminate; thence a continuous frost batter is to be formed to the top rear line of the coping.

It is to be built on a foundation of timber and plank, arranged and placed in like manner as described for the walls above mentioned, but laid on the same level as the floor of the lock; in this case a course of sheet piles, 5 feet in depth, is to be put in at the toe of the wall.

The coping to be 4 feet wide on t p, and in all other respects the material used in the wall must be of like dimensions and of a similar class, and the workmanship throughout executed as described for the cut stone masonry portion of the lock.

At the lower end, the wall is to be made circular and connected with the lower wing of the south wall of the raceway, as indicated on plan.

Dock Walls.—Along the south side of the canal, a retaining wall is to be built from the lower end of the section upward, and at such other places on the north side as may be determined.

The walls to be 3 feet wide at top and have a batter of 2 inches, or more, to the foot on the front side, and on the rear side increase at the rate of 3 inches to the foot for the first 5 feet from the top, thence downward it is to be plumb. Counterforts, 3 feet in length and two feet in depth, are to be placed 12 feet apart, or at such other distances as may be directed, and be carried up to where the frost batter commences.

The wall must be built of an approved class of sound and durable, flat and well-shaped stones, not less than 6 inches thick, 2 feet or more in length, with at least 3 feet area of bed, laid so as to form a proper bond over and with each other in both front and rear; the faces of the stones must be hammered or scabbled to a line corresponding to the position they are to occupy in the work. Headers not more than 7 feet apart and at least 3 feet depth of bed, are to be placed in each course. The coping stones must be at least 10 inches thick and 3 feet wide at top, increasing in width downwards to the batter on both sides. No piece to be less than 3 feet in length.

The whole of the stones to be laid in full beds of hydraulic cement mortar, prepared as previously described, and the different courses grouted as the work progresses. Black limestone, such as used for ordinary building purposes in Montreal, will not be allowed in the work.

In rear of these walls (if so directed) a space of 15 inches in width is to be made up, for such a height as may be requested, with small stones, quarry waste or gravel, well rammed.

As already stated, the present lock is to be taken down to at least 2 feet below the surface level of the lower reach, and that portion of the stone fit for backing put either on the service ground already mentioned or some other place provided by and at the expense of the contractor. The refuse material, or such as may be unsuitable for use in the work, is to be placed in the spoil banks or otherwise disposed of in such a manner as the Department of Public Works may approve. The taking down of the walls and depositing the material as above stated will be paid for by the cubic yard of wall removed. All the stone suitable for backing, taken out of the walls of the old lock, may be used in the new work.

The face work must, as already stated, be wholly of approved gray limestone, of the dimensions and prepared as described for the new lock. It is, however, to be adapted and arranged to suit the openings, quoins and piers of the present structure.

The breast and curved walls at the upper end of the lock are to be overhauled, and such new stone furnished for them, and repairs made, as may be required.

The north lower wing of the lock, or as much of it as projects beyond the rear line of the side walls, must be wholly removed to admit of making a water-tight connection

between the back or end of the centre retaining wall and a range of concrete to be formed in rear of the north side of the lock for its entire length.

The seat for this concrete wall must be formed immediately along by the back of the old lock wall, and sunk to the full depth of the foundation of the new structure, or 5 feet below the bottom of the present lock. Great care must be taken to clean the back of the old wall for the whole distance and height, as the concrete wall (3 feet in width) is to be carried up to at least 18 inches over the line between the old and new portions of the works.

The removal of that portion of the old structure above mentioned, together with building new walls and constructing the centre retaining wall previously described, must be done between the close of navigation in December and the twenty fifth day of April in the following spring, on the contractor being notified by the Department of Public Works to that effect in the early part of November preceding.

The old culvert under the canal, near the middle of the section, is to be entirely removed, and the place it occupies be cleared out to the full depth, so that a water-tight bank can be formed, especially on the south side of the canal.

The removal of the masonry at both ends of the culvert must be done carefully, as the stones, when sound and of a good class, may be used as backing for the new works.

The trunk is of timber framework, lined and cased with plank, all of which must be removed and also the wells at the end. The excavation and refuse materials from the masonry are to be deposited in the spoil bank previously referred to, and the serviceable stones placed where they can be advantageously got at when required.

The old timber work is be disposed of by the contractor, under such arrangements that it will be removed entirely beyond the limits of the canal property.

The removal of the trunk of the culvert and the wells, up to the height of the respective breast walls, will be measured and estimated as "solid," inasmuch as they are nearly filled with silt and sugar refinery waste.

Wellington Street Bridge.

This section, as previously stated, embraces the construction of piers and abutments for a street and railway bridge, either combined or so arranged as to form two separate means of crossing on or near the line of Wellington Street. The removal of the piers, etc., of the present structure, in the manner and at the time directed, is also included.

The water-way is to be in four divisions, the two centre ones of which are each to be 46 feet wide, and form the navigable channels. The piers and abutments are to be of masonry, laid in hydraulic cement mortar, built chiefly of the dimensions and in the manner herein described, or as may be subsequently directed.

The space at and in the vicinity of where the bridge piers and abutments are situated, or from a line in continuation of the east side of the wood basin to the dock wall, on the south side of the canal, downward to the lower end of the section, is to be made 15 feet in depth below water level, except on the north side opposite the old bridge abutments and dock wall, where, for a width of 12 feet alongside of the wall, the bottom is to remain as at present.

The material excavated from this space, as well as from the seats of the piers which are to be 2 feet 3 inches lower, or 17¼ feet below water level, will be deposited at the place and in the manner previously stated.

The centre and rest piers of the bridge are to be parallel to the centre line of the canal; the former to be 27 feet square at the top, and the latter to be 27 feet long by 9 feet thick at top. Two arched culverts, each 7 feet in width and an average of 8 feet in height, are to be formed through them on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least 16 feet below canal surface, and in each case they are on all sides to have a batter of one in twenty-four.

The arch stones of the culverts are to be 21 inches deep, and dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom of the arch or water-way is to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening, and at each end pass 15 inches under the wall, the second course to project one foot into the opening and the third course 6 inches.

The face stones of the piers to be two and three feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth (¼) of an inch; and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of each of the centre as well as the rest piers.

The heart of the wall in each case to be made with flat-bedded stones, not less than 4 feet area of bed and of the full height of the face stone; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch, and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge, when in position, are to be 42 feet long, 11½ feet thick at bottom, the sides of which are to be parallel to the canal, and the ends be at right angles to the face of the pier. They are to be faced on both sides, and throughout be of a like class of material and workmanship, and the foundation for them to be formed at a like depth, as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty-four.

At four feet from the top of these piers, or at such other height as may be required, offsets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, placed twenty-nine feet or more from the piers for the bridge seat. They are to 9 feet thick at bottom, batter one-sixth to one on the face, have counterforts in rear, and in every respect be of a like class of material and workmanship as previously described for the dock walls, except that they are to be laid on a foundation of timber and plank, placed at the same level as that for the piers.

The south abutment, at its eastern end, will connect with the returned end of the dock wall of Wellington Basin, and the one on the north side will connect with the abutment of the old bridge. These connections are to be formed by varying the respective slopes within a distance of 25 feet or more in length on the general line, the bottom of walls being so arranged with reference to each other that the top line in each case will correspond with that of the main wall, both above and below, and the face present a fair winding batter corresponding to the position of the work.

The upper 4 feet of the wall, below the line of the bridge, is to be of cut stone, neatly dressed and boucharded, made square, bevelled, circular, or otherwise suited to the place it is to occupy, and is to be laid to three-sixteenths of an inch mortar beds and joints, and as regards dimensions of stones, dressing and all other respects, be at least equal to the cut stone masonry described for the lock.

The centre piers, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge, and break joint properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top side must have a fair surface, neatly boucharded, and where required the outer top arrises are to be rounded off.

The pivot-stone to be not less than six feet square and two feet depth of bed; the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones for a width of four feet is to be twenty-four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge will be 10 inches in thickness at the centre of the road, curved on top so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward, one of which at each end of the bridge must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers, and finished with coping as indicated on the plans.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments they are to be laid either longitudinally or transversely as may be required.

In all cases the spaces between the timbers must be filled with a good description of puddle or concrete as may be directed.

The covering plank to be of pine, three inches thick, laid obliquely, and fastened to the timbers with 1¼ inch white oak treenails 8 inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers, if the officer in charge considers it necessary.

FENDERS—are to be placed horizontally on both sides of the water-way, extending for some distance above and below the bridge, each of which will be formed of two pieces 8 x 12 inches, of white oak, kept 2 inches apart by means of white oak blocks 9 x 12 x 2 inches, placed vertically 6 feet apart from centre to centre.

The pieces forming the fenders are in each range to be connected by means of double oblique joints let 3 inches or more into and on to each other respectively. The joints in the inner range must be at least 12 feet on either side of those on the outside.

They are to be fastened to the piers with rag-bolts one inch diameter, and to the cribs subsequently described with screw bolts; in both cases they are to be put on and secured in such a manner as may be directed.

CRIB WORK.—Between the centre and rest piers, as well as above and below them; also above and below the piers for the seat of the bridge, crib work is to be constructed to form bearings for the fenders and for the protection of the respective structures.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 27 feet wide at top, increasing downwards on both sides at the rate of one in twenty four, and through the middle of them, longitudinally, a clear water-way of such dimensions must be formed in two divisions or otherwise as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge, there are in each case to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of ends of the cribs. The bottom to be of 3-inch plank, well fastened with pressed spike, and the top to be formed of pieces not less than 10 inches thick and of the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges, and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$ inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends, and of the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the course immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides, so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie, at the joint between the courses immediately below it, a block $1\frac{1}{2}$ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing

down through the course on which it rests, the block and course under it and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them, and be secured by bolts of similar dimensions and in like manner as described for the transverse ties, into which they are to be notched, and fastened at the crossings by means of white oak treenails 2 inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside, and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: One at or near each angle, and another in the centre, making in all six vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spike, five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces, and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from 8 to 10 feet or more; but they must be so arranged that the upper length, in all cases, shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than 3 feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the side next the channel.

The whole interior of the crib work, except the water-ways, to be filled with an approved class of moderate-sized stone ballast.

For the protection of the structure and guide piers three clusters of piles are to be driven within range of the centre pier at suitable distances above and below it; they are to be connected by means of thorough-bolts, straps, etc., and stand one foot or more over the cap-pieces as may be required. Piles are also to be driven for the protection of the crib work, placed above and below the seat piers of the bridge.

In case the piers and abutments for two swing bridges are to be built, their dimensions will generally be less than if railway traffic and public travel are both to be served by one structure, but in either case the class of workmanship will be the same.

Contractors are therefore expected to bear in mind that the prices tendered for the different items of work are understood to be applicable in either case, *i. e.*, whether it be decided to build one bridge or two bridges.

The superstructure of the bridges—both the swing and fixed portions of them—as well as the necessary machinery for working them, will be made a separate contract.

REGULATING WEIR AND RACEWAY—to be contracted on the north-west side of the locks in the position indicated on the general plan.

The weir is to be of masonry built on a foundation of timber and plank, laid at the level of 5½ feet below the surface water line of the lower reach, and the bottom of the raceway is also to be of timber and plank laid at a like height as the floor of the weir; the side walls are also to be of masonry.

The walls which form the sides of the head race are to extend in a slightly oblique direction on a line corresponding to that of the old canal, and on the north-easterly side an opening is to be left to admit the water supply to such of the existing mills as are situated east of the main road. Immediately above this opening, abutments are to be built for a fixed bridge to be constructed for public traffic over the water-way.

The head race will have a mean width of 49 feet between the side walls—the weir to have a spill-way of 49 feet, exclusive of the centre pier, and the tail race have a width of 32 feet at the water level of the lower reach.

EXCAVATION.—The pit for the weir is be to excavated to a width of 72 feet and a length of 40 feet, and the lower raceway for a distance of 400 feet is to be made 41 feet in width and for 46 feet at the upper end it will be $\frac{41+72}{2}$ all of which is to be excavated 5½ feet below the surface water level of the lower reach.

The bottom throughout must be trimmed off to a fair surface at the level above stated, and the material not otherwise required for banks hauled and disposed of at the place and in the manner previously described.

A slope of one to one will be allowed on both sides of the weir, and a slope of one-half to one on both sides of the tail race.

The masonry of the old lock which it will be necessary to remove, whether in connection with the weir or the new lock, must be done at the time and in the manner directed, and the stone considered by the officer in charge suitable for backing in the new work may be placed where it can be used advantageously for that purpose.

THE FOUNDATION—to be formed of pine timber 12 inches square, laid transversely one foot apart from the upper end of the weir to the lower end of the tail race.

Under the walls of the head race and bridge abutments the timbers are to be laid longitudinally.

The timbers for the tail race must be of the full length to extend across the race and from rear to rear of the side walls; those for the weir may occasionally be in two lengths, provided the centre portion of the end of one piece enters horizontally 4 inches into that of the other, and underneath there be a binding piece 10 feet in length, secured by two wrought iron screw-bolts 1⅛ inch in diameter.

The floor timbers of the weir are to be laid so as to rest on mud sills placed within the line of the side walls and on the bottom throughout their entire length; mud sills, if so directed, are also to be laid under the bottom timbers of the raceway at about the front line of the side walls.

In case mud sills are put in, they are to be placed and arranged in like manner as those described for the foundation of the lock.

The spaces between the timbers, as well as alongside of the mud sills, are to be filled with the best description of properly-made puddle, well beaten down; otherwise concrete, either in part or as a whole, may be used if considered necessary by the officer in charge.

At the lower end of the raceway an apron of timber and plank 16 feet or more in length is to be formed at the same level as that of the floor of the new lock, the

timbers of which must be of a length to extend from the rear of the north wall to the longitudinal timbers which form the foundation of the retaining wall below the lock.

At the lower end of the apron a course of 4-inch sheet piles five feet in length is to extend across the entire water-way, also a similar course of sheet piles is to be put in above the breast wall that is to be built across the raceway at a point immediately above the apron, as indicated on the plan.

There are to be four ranges of sheet piles across the foundation of the weir, that is to say, one at the upper end, another at the lower end—one above and another below the breast wall.

There must also be a course of sheet piles across the raceway immediately at the junction of the oblique and straight portions and at such other places as may be required, and on the face sides and ends of the road bridge abutments ranges of sheet piles are to be put in, as well as on both sides of the centre pier of the bridge, in case it is determined to build one in that position. They are generally to be of pine plank 4 inches thick, 6 feet long, jointed, prepared and fastened, and the trenches cut for their reception made of the size, and subsequently well filled with puddle, and the whole work connected with them executed in the manner described for those in the lock foundation.

The range of piles in line with the upper side of the breast wall of the weir must extend beyond the rear of the side walls and into the solid bank on the north side, and on the south side to the back of the masonry of the new lock, and in both cases to be carried up to water line of the upper reach.

FLOORING—to consist of two courses of approved pine plank. The first, 3 inches in thickness, is to extend over the whole area of the foundation of the weir, raceway and apron; and the second course, 2 inches thick, is to be laid between the side walls for the entire space below the breast wall of the weir. They are to be well jointed and in every respect be laid to break joints and be fastened—the lower course with white oak treenails and the upper course with pressed spikes—and in every other respect the work connected with them must be done as described for the floor of the lock.

On the foundation timbers for the walls of the head race and bridge abutments above the weir, and also on the foundation of the retaining walls, below both the present and the new lock, the planks are to be laid obliquely and either fastened with treenails or pressed spikes, as may be directed.

MASONRY.—The walls are to be built in the positions and generally be of the respective dimensions marked or represented on the general plan; they must consist throughout of an approved class of sound and durable stones, free from seams and other defects, laid in full mortar on their natural beds.

It is to be clearly and distinctly understood that what is described and intended to be classed and estimated as weir masonry is that portion of the work between the ranges of sheet piles at what is called the upper and lower ends of the weir. Under this head is included the breast wall, wing walls and centre pier.

WING WALLS—to be 7 feet thick at bottom, face to be "rock work" with a batter of one in twelve, the stones to be at least 2 feet long in line of wall, 18 inches and 2 feet depth of bed in the alternate courses, with headers 3½ feet depth of bed, and not more than 10 feet apart in every course—the whole to be dressed and laid so that the beds and end joints shall not exceed three-eighths (⅜) of an inch. The

back of the walls are to be carried up plumb to within five feet of the top; thence batter to the rear line of the coping which is to be 3 feet in width.

BREAST WALL—to be 9 feet in width at bottom, 4 feet at top, and 12 feet 8 inches high, built of stones 2 and 3 feet depth of bed in the alternate courses, with headers in each course 4½ feet deep, and not more than 9 feet apart, all of them must be dressed so that the horizontal and vertical joints shall not exceed ¼ of an inch. The upper side of the wall to be plumb, and the faces of the stones dressed fair and smooth to receive the framework of the sluices, and the lower side is to be rock faced work laid to a batter of about 4¾ inches to the foot rise.

There are to be eight sluice-ways through this wall, each 4 feet wide and 5 feet high, the top, bottom and sides of which are to be dressed smooth. The sills under them and lintels over them to be from 14 to 15 inches in height and 6 feet long, each dressed so as to lay to close and full joints, and present a fair surface through the respective openings.

All the piers between the sluice-ways, except the supporting pier in the centre, must be made of stones, dressed to the proper width (2 feet), bonded over and on to each other at least one foot.

CENTRE PIER—to be 4 feet 9 inches in width at the floor, carried up to such a batter on both sides that the top shall be 3½ feet in width. This pier, coping excepted, may be made of two widths of stone, provided there are double headers in each course not more than 8 feet apart.

The arrises of all the face stones on both the upper and lower sides of the breast wall, the centre or supporting pier, the sills, lintels and piers of the sluice-ways must all be kept good, and the whole dressed and laid so that the horizontal and vertical joints shall not exceed one-fourth of an inch.

Near the upper end of the weir, checks are to be cut in the face of each of the wings and on both sides of the centre pier for the full height of the walls, for the reception of stop logs. Below these checks a cross wall 2 feet .0 inches wide and 2½ feet high, is to be built of blocks of stone the full width, properly bedded and bonded and well secured with dowels and vertical bolts, in such a manner as may be required.

COPING.—The breast wall coping must be at least 16 inches high and 4 feet wide on top, increasing in width downward to the batter of the wall. The lower bed and joints must be kept full throughout, and the top dressed fair so as to have a declivity of one inch toward the up-stream side.

It is to be in lengths of not less than three and a half feet, and be connected with dowels at the joints, and secured with bolts to the course underneath.

The coping of the wing walls and centre pier to be at least 12 inches in thickness, the former three feet and the latter three and a half feet in width, all of which must have full beds and joints, and be neatly boucharded on top.

In addition to the range of sheet piles to be placed in line of the breast wall, a counterfort of masonry 4 feet thick and 6 feet in length is to be carried up in connection with each of the wing walls to the height of the water level of the upper reach.

BACKING—to be of a like class of stone and workmanship as described for that of the lock walls.

A puddle bed 3 feet in width is to be carried up in rear of the side or wing walls to the full height of the water level of the upper reach. The material used for this purpose, as well as for the puddle between the foundation timbers, and for the sheet pile trenches must be of the best and most suitable kind that can be obtained on the section or in the vicinity of the work.

SLUICE GATES—to be built of the best quality of white oak plank, 6 inches thick at the centre, and gradually rounded off on both sides to $3\frac{1}{2}$ inches at the end. Each gate to have a top and bottom plate of cast iron, connected with bolts of wrought iron seven-eighths ($\frac{7}{8}$) of an inch in diameter, passing through the gate, and to have straps of wrought iron 3 inches wide and three-eighths ($\frac{3}{8}$) of an inch thick on both sides of the gate, within three inches of each end; the straps are to be let in flush, and fastened at distances not more than 6 inches apart, with rivets $\frac{1}{2}$ an inch in diameter countersunk into the straps. The top plates are to be $2\frac{3}{4}$ inches deep, and those at the bottom $6\frac{1}{2}$ inches deep, each to have a flange from the centre outwards on opposite sides.

The gates are to revolve on the centre, on pivots working into the bottom plates of the gates, and on the top of each a disc of steel or hard brass is to be placed, and have a brass collar and lining. The pivots are to be $3\frac{1}{2}$ inches diameter, connected with plates 9 inches square and 2 inches thick, let into the sills of the sluice-way, and secured to them by fox-bolts.

The gates are to be arranged in a framework of oak timber, 6 inches thick and 12 inches wide, fastened with fox and key-bolts to the piers and lintels of the sluice-way.

The vertical posts of the frame are to be bevelled so as to form a bearing for the sides of the gates when closed, and stops are to be placed in the interior as directed.

The turning rods are to be of wrought iron 3 inches in diameter, of sufficient length to pass through the gates and stand six inches over the side timbers of the platform to be formed over the weir. They are to be keyed into the plates on the gates and secured into the masonry with suitable iron brackets, the upper end of them to be made square, on which a movable handle is to be fitted; and they are further to be connected with racks on the platform, made so as to secure the gate in the position required.

RACEWAY MASONRY.—Above and below the weir, the sides of the raceway are to be formed of "random coursed masonry," that is to say, that both beds of the face stones must be level, but continuous courses will not be required.

Above the wier, the side walls are to be $12\frac{1}{3}$ feet high and $6\frac{1}{2}$ feet wide at bottom, the faces of which are to have a batter of 1 in 12, and the back to be carried plumb to within 5 feet from the top, thence batter to the rear line of the coping. In rear of these walls and in connection with them, counterforts 4 feet long and 3 feet deep are to be carried up 12 feet apart to within 5 feet of the top of the bank.

From the weir downward to opposite the lower end of the new lock, the south wall of the raceway is to be 15 feet in height, and form the tail of the weir to the upper end of the parallel portion of the race; the north wall is to be made of a like height. On both these parts of the walls the face is to have a batter of 1 in 12. Below the points above mentioned to the lower breast of the raceway the side walls are to be 8 feet high, $5\frac{1}{3}$ feet thick at bottom, batter one-sixth to one on the face, and the back to be plumb to within 4 feet of the top, thence batter to the rear line of the coping. From the lower breast downward the walls on both sides will be 19 feet high, and of the form and dimensions represented on plan.

For a distance of about 70 feet below the end of the weir, and for a height of 7 feet over the floor, the side walls are to be recessed or stand back 2 inches to receive a lining of plank to protect the walls from the direct action of the water discharged over or through the weir.

This lining is to be of well-jointed two-inch pine plank, fastened to the flooring, and at other places to three bond timbers 4 x 5 inches, built into the face of the walls, as the works proceed. The walls above referred to are, as already stated, to be "random coursed work," built of large-sized, sound, flat and well-shaped stones, properly bonded over and with each other. The stones forming the face of the walls must be picked or scabbled to lines suited to the position they are to occupy in the work ; and in every 15 inches in height of the walls there must be headers of at least 3 feet depth of bed, placed not more than 7 feet apart.

The coping stones must be of full dimensions, three feet in width on top, increasing downward to the batter of the wall ; they must be at least 10 inches in height and 2½ feet in length, and be neatly picked or scabbled on the face and top ; the lower bed and ends must also be kept full, so as to make close joints throughout.

The bridge abutments at the upper end of the raceway are to be 7½ feet thick at bottom, the face of which will have a batter similar to that of the adjoining walls, and the back be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, which is to be 3 feet in width and at least 12 inches in height.

If considered necessary, the width between the abutments of this bridge may be increased and a centre pier put in to form a bearing for the superstructure.

In either case the work, as well as that of the breast wall at the lower end of the raceway, is to be of "rock work" of a like class as that described for the masonry of the wing walls of the wier.

All the masonry connected with the weir, bridge abutments and raceway must be laid in approved hydraulic cement mortar, and the walls be properly grouted, the mortar, etc., to be prepared as described for the lock in a preceding part of this specification.

Contractors should bear in mind when tendering that black limestone, such as used for ordinary building purposes in Montreal, will not be allowed in any part of the work connected with the section.

CONCRETE,—where used, must consist of an approved quality of stone broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand in such proportions as may be required.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls ; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way and of such dimensions as may be directed.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan contemplated in this specification and the direction of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed working drawings arranged, modified and adapted to the locality and for all such parts of the structures as may be required will be furnished as the works proceed.

The removal of the present piers and abutments of Wellington Street Bridge to be tendered for by the cubic yard; this rate to include the removal of all mason work, crib work or whatever may be necessary to clear out the channel to the required capacity; the work to be done at the time and in the manner directed by an officer entrusted with that duty by the Department of Public Works.

The unwatering of the foundations of the piers and abutments of Wellington Street Bridge to be tendered for in *one bulk sum*. Contractors should, however, bear in mind that the new piers and abutments may have to be built at three or more different times, and the bulk sum tendered for unwatering should embrace the construction of coffer dams, pumping, bailing, removal of all snow and ice and whatever may be required to lay the several parts or all of the foundation dry at the respective times when the work is directed to be done by the Department of Public Works.

The unwatering of the foundation for the side or dock walls from the Wellington Basin upward to be tendered for at a fixed rate for every *one hundred lineal feet* of foundation formed and wall built. This rate to include formation and removal of dams, removal of water, ice, snow, etc., during the progress of the respective portions of the work.

The unwatering of the foundation for the retaining wall below the present lock, also for the foundation of the bridge piers above the present lock and for the foundation of the concrete wall in rear of the lock to be tendered for in *one bulk sum*, which must include the formation of dams and their removal, also the removal of all water, snow and ice from the respective places during the progress of the works.

The unwatering of the foundation of the new lock, retaining wall below it and bridge piers, etc., above it, including the formation of all coffer dams and other works necessary to enable the lock pit and other parts of the foundation to be laid dry, to be tendered for in *one bulk sum*, which must embrace the removal of all water, snow and ice during the progress of the works and up to the time of their entire and satisfactory completion.

The unwatering of the pit for the regulating wier, head race and apron below it, to be tendered for in *one bulk sum*, which must include the construction of all coffer dams and other arrangements necessary to enable the respective portions of the works to be laid dry,

and embrace the removal of all water, snow and ice during the progress of the operations and up to the time of their full and satisfactory completion.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The temporary head gates and raceway on the south side of the canal, as well as the road crossing at St. Gabriel, will be made, provided and maintained by and at the expense of the Department of Public Works.

The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads or for placing and preparing materials beyond the limits of the lands previously mentioned herein as set apart for such purposes.

He must also provide and deliver, at his own cost, all necessary materials and furnish all plant, tools, vessels, machinery, equipments, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works as herein described and the instructions that may from time to time be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty-fifth day of April, 1878.

JOHN PAGE,

Chief Engineer of Public Works.

OTTAWA, 27th September, 1875.

APPENDIX No. 39.

LACHINE CANAL.

SPECIFICATION of the Work to be done on SECTION No. FOUR of the Enlargement.

This section extends from about the centre of the By-wash situated above the Grand Trunk Railway Swing Bridge, to within a short distance of the head of the Island above St. Gabriel Lock, or from Station No. 88 to Station No. 50, a distance of 3,800 feet.

The work upon it consists in widening and deepening the prism of the canal and depositing the material excavated within the distance stated, the construction of piers and abutments for what is called Brewster's Bridge, also the construction of piers and abutments for the Grand Trunk Railway Swing Bridge and all alterations to the culvert under the canal for passing the main pipes connected with Montreal Water Works.

The water-way is to be enlarged to a mean width of two hundred feet and sunk to the depth of fully four feet below the top of the lower mitre sill of the present lock at Côte St. Paul. The foundations for the bridge piers, etc., are to be placed sufficiently low to correspond with fifteen feet of water in the reach and fourteen feet on the mitre sills of the new lock at Côte St. Paul.

The excavation connected with the increased width of the channel is intended to be on the south side, and the new piers, etc., for the bridges will also be on the south side of the present ones, as indicated in red on the general plan exhibited.

The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined, also of altering the position of any or all of the structures one hundred feet either to the right or left, or of placing any or all of them one hundred feet either upward or downward from that indicated on the plan, or in such other position as may be considered the most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

Where the present banks of the canal are cut into or are cut away by the widening at places where they pass through low ground or are immediately alongside of it, a new bank must be formed or an additional width given to the present ones, as circumstances may require. In all such cases the space to be occupied by the new part of the bank must be cleared of all sods, turf, muck or other objectional matter, and all loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the banks, and seats prepared for them.

The new banks must be formed of the best description of material that can be obtained in the vicinity and *at all places where the banks or any part of them require to be made water-tight the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time ;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

To render the banks at such places still more secure, as well as at any other place where the officer in charge may consider necessary, a trench from 4 to 6 feet in width, of such a depth and length as may be directed, is to be excavated at the front line or in such other position under the towing path as may be subsequently determined, in which a puddle bank or wall is to be carried up to a foot or more over water line.

The sides to be made vertical or to such inclination between that line and one and a half horizontal to one vertical as may be subsequently determined.

Towing Path.—At all places where the widening of the prism is on the south side of the present channel, a towing path of the full width must be continued and formed either as a whole or in part, as may be required.

It is to be made 18 feet in width and of a like elevation over the water line as the one now in use ; at places where there is a bank in rear of it or where one may be formed of a greater height, a ditch 2½ feet wide at bottom must be cut at the foot of the slope, towards which the top of the track-way shall have a declivity of one foot transversely.

The bottom of the ditch to have such an inclination as will carry the water freely to off-take drains formed at such places as circumstances may require.

In case the material excavated from the widening or deepening of the channel and foundation of the structures or any considerable portion of it, is deposited alongside of the towing path, arrangements must be made so that the bank shall be carried up to an uniform height of twelve feet or more over the surface water level of the canal and to such side slopes as may be directed.

If the excavation is deposited at other places on canal property or on any other property authorized by the Department of Public Works, the material must be spread over such an extent of surface and made of such a height as may be directed, within the range and under the conditions subsequently referred to in this specification.

The principal part of the excavation on this section will be clay, but the lower part of it is of a hard nature and it is probable that rock may be met with before getting to the full depth, especially in the foundations for the piers and abutments of the bridges.

It will be observed from the situation of the work that a large proportion of the widening and deepening can be done by machinery during the summer months, provided proper precautions are adopted to guard against interfering with the navigation. Some of these precautions consist in making new banks and strengthening the present ones where required before proceeding with the under-water work, at all events to an extent that might have a tendency to weaken or endanger them; the maintenance at all times of a clear and moderately passable towing path, etc., etc. Contractors will therefore be expected and required to provide the necessary equipment for proceeding with the work as above stated, and be fully prepared to move, haul, transport and elevate the material in such a manner as will enable it to be expeditiously taken to and deposited at the places decided upon, unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way in a more advantageous manner, within the time agreed upon for its completion.

On the lower two-thirds of the section there will be no "spoil ground" adjoining the canal for the material excavated in widening and deepening the channel or foundations of bridges, etc., and as the contractor cannot be allowed to pass mud scows through the lock, at either end of the reach, tenders for the excavation on the section will be received in two different forms, as follows :—

1st—On the understanding that one-third of the entire quantity of excavation on the section and in foundations of the structures can be used in making up the banks, from the lower end of the section upwards, and deposited within a distance varying from 30 to 130 feet from the water line of the enlarged canal, and on the upper one-third of the section. The other two-thirds of the quantity to be placed at a distance varying from 400 to 1,600 feet from the water line of the canal, at such places as may be directed, within a distance of one mile and a half along the canal, from the lower end of the section.

2nd—On the understanding that after the banks of the canal are made up to the width and height required, the contractor shall find, at his own cost and expense, deposit ground for all other parts of the material excavated from the widening and deepening, and from the foundations of structures, etc., as may not be required by the Department of Public Works for embankments or for other purposes.

It is to be clearly and fully understood that the whole of the work to be done on this section (No. 4), for the deepening and enlarging of this canal, will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those parts of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks), at short distances apart, along the whole length and breadth of that part of the present canal within the boundaries of the section. A duplicate copy of the cross-sections, made from these levels and soundings, will remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

Brewster's Road Bridge.—This section embraces the construction of piers and abutments for a swing bridge, intended to take the place of the present means of crossing the canal at Brewster's Road. The removal of the piers, etc., of the old structure in the manner and at the time directed is also included.

The water-way is to be in *four* divisions, the two centre ones of which are each to be 46 feet wide, and form the navigable channels. The piers and abutments are to be of

masonry laid in hydraulic cement mortar; built chiefly in the form, of the dimensions, and in the manner herein described, or as may be subsequently directed.

In the vicinity of where the bridge piers and abutments are situated, a space of 190 feet in length and 180 feet in width is to be sunk to the depth of fifteen feet below water level, and the sides are to be made to a slope of one horizontal to one vertical.

The material excavated from this space, as well as from the seats of the piers which are 2 feet 3 inches lower, or 17¼ feet below water level, must be hauled to near the upper end of the section and deposited there, on the spoil ground previously mentioned.

The centre and rest piers of the bridge are to be parallel to the centre line of the canal; the former to be 18 feet square and the latter 18 feet long by 9 feet thick at top. Through each of them an arched culvert, 8 feet in width and about 8 feet in height, is to be made, on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least 15¾ feet below canal surface, and in each case they are on all sides to have a batter of one in twenty-four.

The arch stones of the culverts are to be 21 inches deep, dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom of the arch or water-way is to be of dressed and properly-jointed stones, of a size that two of them will make up the width of the opening, and at each end pass 15 inches under the wall, the second course to project one foot into the opening, and the third course 6 inches.

The face stones of the piers to be two and three feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than 9 feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case to be made up with flat-bedded stones, not less than 4 feet area of bed, and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch, and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge, when in position, are to be 10½ feet thick at bottom, the sides of which are to be parallel in the canal, and the ends be at right angles to the face of the pier. They are to be faced on both sides, and throughout be of a like class of material and workmanship, and the foundation for them be formed at a like depth, as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty-four.

At four feet from the top of these piers, or at such height as may be required, off-sets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry, placed thirty feet or more from the piers for the bridge seat, and the foundation for them laid at 12 feet below surface water line, or at such other level above or below that point as circumstances may require. They are to be 7½ feet or more in thickness, carried up to a batter of one in twelve on the face to the water line, and made plumb in the rear to within 4 feet of the top, thence the wall will

diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized well-shaped stones, laid level in full mortar, and properly bonded throughout the wall.

The centre piers, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge, and break joints properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for rollers of the turntable. They must be full-bedded throughout, and dressed so as to lay to joints not exceeding one-fourth of an inch; and the top side must have a fair surface, neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and two feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed to the width, and be at least 3½ feet in length.

In the centre of the rest piers one of the coping stones, for a width of four feet, is to be twenty four inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

The coping on the piers for the seat and the abutments for the road bridge will be 10 inches in thickness at the centre of the road, curved on top so as to be eight inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built, 4½ feet square at base, diminishing upward—one of which, at each end of the bridge, must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers, and finished with coping, as indicated on the plans.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments they are to be laid longitudinally or transversely as may be required.

In all cases the spaces between the timbers must be filled with a good description of puddle or concrete as may be directed.

The covering plank to be of pine three inches thick, laid obliquely and fastened to the timbers with 1½-inch white oak treenails 8 inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

FENDERS—are to be constructed on both sides of the channel ways, extending for some distance above and below the bridge, as represented on general plan. Those in connection with the seat piers for the toe of the swing are to be formed by means of piles, caps, braces and wale pieces, all of white oak timber. The piles are not

to be less than 12 inches diameter at the small end, driven from 6 to 10 feet into the bottom and be about 6 feet apart—at the anchor timber two piles will be driven on the line of the fenders and one about the middle of each tie timber. The fenders proper are to be formed of two pieces each 8 x 12 inches, of white oak, kept 2 inches apart by means of white oak blocks 9 x 12 x 2 inches, placed vertically 6 feet apart from centre to centre. The different pieces in each range are to be connected by means of double oblique joints let 3 inches or more into and on to each other respectively. The joints in the inner range must be at least 12 feet on either side of those on the outside. They are to be fastened to the piles with bolts one inch diameter and also to the centre cribs subsequently described; in both cases they are to be put on and secured in such a manner as may be directed.

In case that piles cannot be driven sufficiently into the bottom to form the necessary fenders for the bridge, framed bents of white oak timber 12 x 12 inches may be used for that purpose. To enable the latter plan to be carried out a trench must be cut 18 feet below water line for the reception of sills, into which the posts of the bents are to be securely fastened.

At bottom of canal, and at such height over it as directed, the posts are to be connected with horizontal ties, and, both longitudinally and transversely, ranges of diagonal braces are to be framed vertically in between them and well secured with straps and bolts.

At top the posts are to be connected with caps, ties and wale pieces, framed, bolted and secured as previously described.

Crib Work.—Between the centre and rest piers, as well as above and below them, and, if directed, above and below the piers for the seat of the bridge, crib work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portions of the work are to be the same width as the stone piers, *i.e.*, 18 feet wide at top, increasing downward on both sides at the rate of one in twenty four, and through the middle of them, longitudinally, a clear water-way of such dimensions must be formed as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere, of such shape and dimensions as may, together with the centre openings, gave an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge there are in each case to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of ends of the cribs. The bottom to be of 3-inch plank, well fastened with pressed spike, and the top to be formed of pieces not less than 10 inches thick and of the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges, and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$ inch diameter is to be driven through the dovetail.

Cross Ties—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends and of the full length of the outside width of the cribs.

They are to be placed not more than 10 feet apart and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the course immediately below and above.

Their ends are to be dovetailed 3½ inches into the timbers under and over them, the dovetail to splay 1½ inches on both sides, so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie, at the joint between the courses immediately below it, a block 1½ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt 2½ feet long, ⅞ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties 10 inches thick are to be framed into and dovetailed between the end timbers, have blocks under them and be secured by bolts of similar dimensions and in like manner as described for the tranverse ties into which they are to be notched, and fastened at the crossings by means of white oak treenails 2 inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: One at or near each angle and another in the centre, making in all 6 vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spike, ⅝ of an inch in diameter, two driven through each plank into each of the lowest side pieces and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from 8 to 10 feet or more, but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers the cross ties are to be placed not more than 3 feet apart so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the side next the channel.

The whole interior of the crib work, except the water-ways, is to be filled with an approved class of moderate-sized stone ballast.

For the protection of the structure and guide piers, three clusters of piles are to be driven within range of the centre pier at suitable distances above and below it; they are to be connected by means of thorough-bolts, straps, etc., and stand one foot or more over the cap-pieces as may be required. Piles are also to be driven for the protection of the framed bents or crib work placed above and below the seat piers of the bridge.

The superstructure of the bridge, both for the fixed and movable parts, as well as the machinery for working the latter, will be made a separate contract.

GRAND TRUNK RAILWAY BRIDGE.—The new piers, abutments, fenders, etc., for this structure will for the most part be similar to those above described, but made of dimensions and in all other respects suited to the swing or movable parts of the present bridge.

The excavation at and in the vicinity of the bridge must be well advanced, the foundations for the centre piers and seat pier on the north side prepared, and the walls carried to about the height of the present canal bottom by the middle of April, 1877.

The whole of the works connected with the piers and abutments must, however, be completed by the first day of March, 1878, so as to admit of the bridge being shifted to its new position, and allow time for the removal of the present piers before the opening of navigation in the spring of 1878.

Contractors should clearly and distinctly understood that all the works connected with building the new piers and abutments for this bridge, as well as those for the enlargement of the canal at this place must be done without in any way or shape endangering, interrupting or interfering with traffic on the Grand Trunk Railway. The carrying out of these conditions will be rigidly insisted upon, a fact which should be borne in mind by parties when tendering for the work, and also that the contractor will be held strictly and legally liable to the proprietors of the railway, the public or individuals for any damage, loss, accident or detention which may be sustained through his acts, whether the same arise from oversight, neglect or from a desire to proceed with the work expeditiously, or from any other act or cause whatever.

The removal of the present piers and abutments of both the railway bridge and that at Brewster's Road, is to be tendered for by the cubic yard, the rate in each case to include the removal of all mason work, crib work, piles, or whatever may be necessary to clear out the channel to the required capacity; the respective works to be done at the time and in the manner directed by an officer entrusted with that duty by the Department of Public Works.

In order to obtain the required depth of water in the canal, the top part of the culvert, for passing one set of the main pipes for Montreal Water Works, must be removed, and the sides of it cut down as low as the floor. When this has been done, a range of sheet piles, or two if necessary, must be put in on both sides of the canal, and arranged so as to entirely surround the pipes, and extend for such a distance on all sides of them as circumstances may require.

At these places such a width and extent of puddle bed or bank must be formed to guard against leakage, or whatever other precautions may be considered necessary by the engineers of the Department of Public Works, in conjunction with the authorized officers of the city corporation of Montreal.

The contractor to state a rate per cubic yard for the removal of the puddle, concrete and timber work, down to the floor, the measurement to embrace the entire area of the culvert, except the rectangular space between the bottom, top and sides of the pipes.

In case it should be determined to remove the culvert entirely, the work must be done at the rate stated in the tender (contractor not to disturb or interfere with water pipes).

In either case the timber and plank, iron or other material taken out of the culvert is to remain the property of the city corporation, if claimed about the time when first removed.

The inside faces of the banks or sides of channel are to be protected in some one or any two, or it may be partly in each of the three following ways, as may be subsequently determined:—

1.—By a covering of pitched stone, of an approved class, laid at right angles to the face, on about twelve inches in depth of quarry waste or gravel. The pitched stone to be in regular courses, varying, from *four* to *eight* inches in thickness, and from a depth of twenty-two inches at the bottom part, to a depth of sixteen inches at the top-water line, laid throughout in coarse sand or fine gravel, and have the joints in the respective ranges properly broken over and with each other.

Where the bottom is clay or other material of that kind, the first tier of stones is to be let in their full depth, in the position above mentioned, and laid so as to form a toe support to the wall. The whole of the stones to be well rammed and beaten down to a fair uniform surface.

2.—Making the inclination of the bank one-half horizontal to one vertical and facing it with pitched stone 3 feet in depth at bottom, 2½ feet at the water line; stone to be laid on a foot in depth of quarry refuse or gravel and at right angles to the face, in regular courses 6 inches or more in thickness—one-third of the superficial area to be of stone the full depth of bed above stated, the other two-thirds may be made up of two-stones.

The rear part of first or lowest course to be let into the bottom, and on top the coping is to be laid horizontal, 2½ feet in width and 9 inches thick; otherwise the top stones are to form a rounded edge if so directed.

The stones must in all cases bond properly over and with each other, and the whole be executed in a satisfactory and workmanlike manner.

3.—Constructing a wall 2½ feet wide on top, with a batter of 2 inches or more to the foot on the front side, and on the rear to increase 3 inches to the foot for the first five feet from the top, thence downwards they are to be plumb.

The wall must be built of an approved class of sound and durable, flat and well-shaped stones, not less than 6 inches thick, 2 feet or more in length, and have 3 feet area of bed, at least; laid so as to form proper bond over and with each other in both front and rear. The faces of the stones must be hammered or scabbled to a line corresponding to the position they are to occupy in the work.

Headers not more than 7 feet apart, and at least 3 feet depth of bed, are to be placed in each course.

The coping stones must be 2½ feet wide, fully 9 inches thick and not less than 3 feet long.

In rear of the walls, a space of about 12 inches in width is to be made up with small stones or quarry waste, well rammed.

The foundation for the walls in either case to be sunk to 15½ feet below the surface water line of the canal; the sinking of which, below the line of four feet under the top of the mitre, is to form a separate item.

Parties should bear in mind when tendering, that black limestone, such as used for ordinary building purposes in Montreal, will not be allowed on any part of the work connected with the section.

Contractors are requested to submit a price for each of these three different kinds of protection for the banks, subject to the distinct understanding that they provide, at

their own cost, all the necessary materials, and that the work to be done may consist of all *three* kinds, or it may be of *two* of them, or wholly of *one* kind without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

For the purpose of enabling the deepening of the channel, and the widening of it below the water line to be urged forward, the bridge pier and abutments to be built and the present ones removed, alterations to be made at water works culvert, the side walls for the protection of the banks built, etc., the canal will be emptied, as nearly as circumtances will permit, in the early part of December, 1876, and the water allowed to remain out until the latter end of April, 1877.

In December, 1877, the water will be again drawn off, and the canal allowed to remain empty until the latter end of April, 1878.

The contractor's arrangements must therefore be such, and his operations be conducted in such a manner that the whole of the works on and connected with this section shall be done between the time of awarding the contract and the 25th day of April, 1878.

Contractors should bear in mind when "tendering" that a dam must be made at each end of the section—one at the upper end to prevent water passing on to or coming from Section No. 5, and one at the lower end to guard against water passing on to or coming from Section No. 3.

For the purpose of removing surface water, springs, leakage, snow, ice, or any other accumulation of water from foundations of the bridges, culvert, foundations of side walls or at any other part on the section, sufficient pumping power must be provided and placed in the most advantageous positions to lift the water from foundations and other places, as often as it may be necessary, and afterwards lift and discharge it into the River St. Pierre, or of disposing of it in some other way, without allowing it to pass on to the adjoining sections.

Contractors should also keep in view the fact that the respective bulk sums for unwatering the different parts of the works must embrace the construction of all dams, the providing and fitting up of all pumps and machinery that may be required for that purpose, also their full maintenance and removal when directed, as well as the replacing of them as often as it may be found necessary to fully carry out and complete all the work herein described or connected with the enlargement of the canal, as contemplated in this specification. It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work and the foundations of all structures on this section must be embraced in the respective bulk sums stated in the tender.

PUDDLE,—wherever used, must be made of the best description of material for the purpose that can be obtained at any place on the section, or within half a mile of the place where it is to be used. It is to be laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form a puddle bed or wall impervious to water.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock," the former to embrace all kinds of material found in widening and deepening the channel or prism of the canal, forming foundation of piers and abutments for swing bridges, side walls, etc., except absolutely connected "quarry rock" and boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing, hauling and placing the material in spoil bank at the place and in the manner herein stated, forming and grading towing path, berme bank, finishing up embankment in rear of bridge abutments, and doing everything connected with the excavation and banks on the section in a workmanlike and satisfactory manner, agreeably to the design contemplated in this specification.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been executed and completed, the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan contemplated in this specification and the direction of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality, and for all such parts of the structures as may be required, will be furnished as the works proceed.

The contractor must provide, at his own cost and expense, all the service ground that may be required for the purpose of placing and preparing materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipment, labor, and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship, and every contingency connected with the due pro-

secution of the different works, as herein described, and the instructions that may, from time to time, be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty fifth day of April, 1878.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 8th March, 1876.

APPENDIX No. 40.

LACHINE CANAL.

SPECIFICATION of the work to be done on SECTION No. FIVE of the Enlargement.

This section extends from a point nearly opposite the lower factories at Côte St. Paul to about the centre of the present By-wash, situated above the Grand Trunk Railway Swing Bridge, or from Station No. 130 to Station No. 88, a distance of 4,200 feet.

The work upon it consists in widening and deepening the prism of the present canal and depositing the material excavated at the places and in the manner herein stated, construction of side walls, a by-wash and an inverted syphon culvert to carry the water of the River St. Pierre through under the canal.

The channel is to be enlarged to a mean width of two hundred feet and sunk to the depth of fully four feet below the top of the lower mitre of the present Lock at Côte St. Paul; the by-wash and culvert, etc., are to be placed sufficiently low to correspond with fifteen feet water in the reach and fourteen feet on the mitre sills of the new lock at Côte St. Paul.

The excavation for the enlarged channel will be on both sides of the present line, but for fully the lower half of the section it will be chiefly on the south side, and on the upper half on the north side; the new by-wash and the new culvert will both be placed further to the westward than the present ones, as indicated in red on the general plan exhibited.

The Department of Public Works, however, reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side or the other, or of increasing the width on both sides, as may be subsequently determined; also of altering the position of any or all of the structures one hundred feet, either upward or downward from that indicated on the plan, or in such other position as may be considered the most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress without giving cause for any increase or diminution in the prices tendered for the respective items of work.

Where the present banks of the canal are cut into or are cut away by the widening at places where they pass through low ground or are immediately alongside of it, a new bank must be formed or an additional width given to the present one, as circumstances may require. In all such cases the space to be occupied by the new part of the bank must be cleared of all sods, turf, muck or other objectionable matter, and all loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the banks, and seats prepared for them.

The new banks must be formed of the best description of material that can be obtained in the vicinity, and *at all places where the banks or any part of them require to be made water-tight, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time;* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

To render the banks at such places still more secure, as well as at any other place where the officer in charge may consider necessary, a trench from 4 to 6 feet in width, of such a depth and length as may be directed is to be excavated at the front line, or in such other position, under the towing path, as may be subsequently determined, in which a puddle bank or wall is to be carried up to a foot or more over water line.

The principal part of the excavation in both the widening and deepening will be clay, some of it of a hard nature; rock will, however, be found for a stretch of fully one thousand feet at the upper end of the section, at some places a little higher than the bottom line of the present canal; and it is quite probable that at other places rock may be met with before getting to the full depth, or at least a class of material composed of clay, gravel and boulder stones firmly cemented together.

In rock cutting the side slopes are generally to be made *one-fourth* horizontal to *one* vertical, and in earth, or where vertical walls are to be built, the sides are to be made with as little slope as circumstances will admit. At other places the side slopes may vary from one-half horizontal to one vertical, or be made to an angle of forty five degrees; otherwise they may be made one and a half horizontal to one vertical, or of any other inclination intermediate between the least and greatest slopes above mentioned as may be directed.

TOWING PATH.—At all places where the widening of the prism is on the south side of the present channel, a towing path of the full width must be continued and formed, either as a whole or in part, as may be required.

It is to be made 18 feet in width and of a like elevation over the water line as the one now in use; at places where there is a bank in rear of it, or where one may be formed of a greater height, a ditch $2\frac{1}{2}$ feet wide at bottom must be cut at the foot of the slope, towards which the top of the track-way shall have a declivity of one foot transversely.

The bottom of the ditch to have such an inclination as will carry the water freely to off-take drains, formed at such places as circumstances may require.

In case the material excavated from the widening or deepening of the channel and foundation of the structures, or any considerable portion of it, is deposited alongside of the towing path, arrangements must be made so that the bank shall be carried up to an uniform height of twelve feet or more over the surface water level of the canal and to such side slopes as may be directed.

If the excavation is deposited at other places on canal property or on any other property authorized by the Department of Public Works, the material must be spread over such an extent of surface and made of such a height as may be directed, within the range and under the conditions subsequently referred to in this specification.

It will be observed from the situation of the work that a large proportion of the widening and deepening can be done by machinery during the summer months, provided proper precautions are adopted to guard against interfering with the navigation. Some of these precautions consist in making new banks and strengthening the present ones where required before proceeding with the under-water work—at all events, to an extent that might have a tendency to weaken or endanger them; the maintenance at all times of a clear and moderately passable towing path, etc., etc. Contractors will, therefore, be expected and required to provide the necessary equipment for proceeding with the work as above stated, and be fully prepared to move, haul, transport and elevate the material in such a manner as will enable it to be expeditiously taken to and deposited at the place decided upon, unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way, in a more advantageous manner, within the time agreed upon for its completion.

On the upper three-fourths of the section there will be no "spoil ground" adjoining the canal, for the material excavated in widening and deepening the channel or foundations of structures, etc., and as the contractor cannot be allowed to pass mud scows through the lock at either end of the reach, tenders for the excavation will be received in two different forms, as follows:—

1st.—On the understanding that one-fourth of the entire quantity of excavation on the section and in foundations of the structures can be used in making up the banks, from the lower end of the section upwards, and deposited within a distance varying from 30 to 130 feet from the water line of the enlarged canal and on the lower one-fourth of the section. The other three-fourths of the quantity to be placed at a distance varying from 400 to 1,600 feet from the water line of the canal, at such places as may be directed, within the limits of the section.

2nd.—On the understanding that after the banks of the canal are made up to the width and height required, the contractor shall find, at his own cost and expense, deposit ground for all other parts of the material excavated from the widening and deepening, and from the foundations of structures, etc., as may not be required by the Department of Public Works for embankments or for other purposes.

It is to be clearly and fully understood that the whole of the work to be done on this section (No. 5) for the deepening and enlarging of the canal will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those parts of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks,) at short distances apart, along the whole length and breadth of that part of the present canal within the boundaries of the section. A duplicate copy of the cross sections, made from these levels and soundings, will remain on record in the office of the Department of Public Works, and another in the office of the Resident Engineer, and from these, together with

levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

River St. Pierre Culvert.

At or near the place indicated on the plan, an inverted syphon culvert of masonry, in which there will be three arched openings, each 6 feet in width, is to be constructed across under the canal, on a bearing surface of timber and plank, arranged and placed as herein described.

The pit for it will be 296 feet in length, 25 feet of which at the south end, and 24 feet at the north end, must be made 38 feet wide, and at other places it is to be 30 feet wide at bottom; the whole to be excavated to an uniform level surface at the depth of 24¾ feet below the top-water line of the canal. The sides to be made as nearly vertical as the nature of the material to be removed will admit; but as the contractor must assume the risk and expense of removing all slides that occur, he will be allowed a slope of two horizontal to one vertical for those parts of the pit outside of the present canal, and a slope of three horizontal to one vertical for all other parts of the pit in clay cutting. In both cases this allowance for a slope is from the present bottom line of the canal only, or one foot below the mitre sill of the lock at Côte St. Paul.

Foundation Timbers—to be pine, 12 inches square, laid 6 inches apart, transversely to the culvert, or parallel to the canal, the spaces between them and at their ends, must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; or if so directed, concrete must be used for that purpose.

Four ranges of sheet piles of 4-inch well-jointed pine plank, 6 feet in length, are to be put in across the foundation, and extend 3 feet on each side beyond the line of the walls—one at the inner side of the well at both ends of the culvert, and one immediately under the toe of the slope of the bank on both sides of the canal.

Trenches are to be cut for the sheet piles, of such a depth as may be directed, and the spaces must afterwards be filled with puddle.

The sheet piles having been properly prepared and placed in their position, they are to be fastened to a long floor timber laid for that purpose; the puddle to be selected made and put in as subsequently described.

The floor timbers must then be dubbed to an uniform surface to receive the plank, the lowest tier of which is to be 3 inches thick, well jointed with a plane, laid so as to break joints; be driven up close and fastened with white oak treenails 9 inches long and 1½ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid, the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber on alternate sides of the plank.

Masonry.—The three separate water-ways of the culvert are each to be 6 feet wide and 26 inches high to the springing lines of the respective semi-circular arches over them. The abutments are to be four feet thick at the floor line, carried up to a batter of one in twelve on the outer sides, to within 9 inches of the crown of the side arches. Piers to be 2 feet in width, invariably made up of stones the entire thickness; they, as well as the face work of the water-ways and wells, are to be of boucharded or dressed stone, and the masonry throughout must be laid in full beds of hydraulic cement mortar, prepared as herein described.

The face of the abutments may be made of two courses, provided the alternate stones in each course are at least 20 inches and 30 inches depth of bed.

In all cases the bed and end joints must be full, the arrises kept good and the stones be properly dressed.

The piers, as already stated, must be of stones the full thickness (2 feet); the height may be made up in two courses, both face sides to be dressed and the outer ends of the piers rounded and the piers laid so as to bond one foot over and with each other.

The arch stones are to be fully 19 inches deep, and must be at least 8 inches on the soffit, which is to be dressed to the curve, and the beds dressed to radiate truly for their full depth; the end joints kept full, and the various stones must be of such lengths as to break joints properly over and with each other.

The courses are to be so divided that there shall be an equal number on each side of the key stones, which must be at least 8 inches thick on their lower sides when fitted and driven to their proper bearings and places.

The skew-backs, or first course of voussoirs on the piers of two adjoining arches must be made in one stone, and the ring stones must be of such a depth that when dressed and jointed they will connect properly with the different courses of ashlar in the spandrel or retaining walls at the ends.

All the stones of the different courses of the piers, abutments and arches must break joints over and with each other at least twelve inches, and throughout they must be laid in full mortar beds, and driven by means of a heavy wooden maul to joints of one-fourth of an inch.

The well at the north end to be 10 feet wide and 24 feet long. Breast wall to be 5 feet thick at bottom, carried up plumb on both sides to within 4 feet of the bottom of the water-course, where a frost batter will be commenced on the north side and carried up with such an inclination as to terminate at the rear line of the coping, which is to be $3\frac{1}{2}$ feet in width, and of a length to extend at least one foot into the wall on each side.

The wall immediately over the northern end of the arch and also the side walls are to be 6 feet in thickness, and that part of each of them next the well is to be of dressed stone, properly bonded at the angles and over each other. They are to be carried up plumb on the face to the under side of the coping, and the rear sides of them are also to be made vertical up to within five feet of the top bank or adjoining ground, where a frost batter is to be made with such an inclination as will strike a line $2\frac{1}{2}$ feet back from the respective sides of the well, at or near the surface of the ground.

From the point above mentioned upward, the walls are to be $2\frac{1}{2}$ feet in thickness, faced on both sides, and must be made up of stones the full width ($2\frac{1}{2}$ feet), to the under side of the coping, which is to be 3 feet wide on top, project 3 inches on each side, and have the top dressed so as to be one inch higher, for a width of nine inches in the middle, than on either face.

The top of the side walls to have an inclination outwards of about one and a half horizontal to one vertical, except immediately over the breast wall, where the coping is to be level.

The face stones of the wells must be at least 20 and 30 inches depth of bed in the alternate courses, and not less than 2 feet length of face in line of wall. In every course

there must be headers of at least 20 inches length of face and 3½ feet depth of bed, placed not more than 10 feet apart from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stones, when in place, thall not exceed one-fourth of an inch.

BACKING—to consist generally of large well-shaped stones, not less than 5 inches in thickness and three feet area of bed, laid level in full mortar and properly bonded throughout the wall.

The side walls and retaining wall at the outlet on the south side will be similar to those above described, but instead of a breast wall the bottom is to have a slope upwards of about two horizontal to one vertical, and be formed of pitched stone laid in cement mortar and made 18 inches lower in the middle than at the sides.

The faces of the banks at both ends of the culvert, for a distance of 25 to 35 feet, or for such other distances as may be required, are to be protected by pitched stone laid dry, or in such other way as may be subsequently determined.

The spaces between the arches are to be made up with rubble masonry laid in mortar, or with concrete, as may be directed.

In either case a foot in depth of concrete is to be laid over the top of the culvert, and the entire space between the side walls and the bank, as well as over the top of the concrete, is to be made up with the best description of puddle, otherwise it must be provided, prepared and made for such other width and extent as may be directed.

In case rock is found in the culvert pit, the bottom must nevertheless be sunk to the depth previously stated, unless the surface is nearly level at a suitable height and the rock is of a compact nature, when a timber bottom may be dispensed with and concrete be used in rear of the walls instead of puddle.

MORTAR.—The whole masonry of the culvert must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1¼ of clean, sharp sand to one of cement and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar, or otherwise, if considered necessary, must be washed.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of 1¼ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

The by-wash situated on the south side of the canal, near the lower end of the section, is to be taken down, and the stones in it considered suitable for use in the new work are to be piled up at some convenient place in the vicinity, either on canal property or where the contractor may have secured a right to service ground; the refuse material is to be taken to the spoil ground, or be otherwise disposed of in such a way as may be approved by the Department of Public Works.

In case a new structure is built for a like purpose as the present one, it will be placed a short distance further to the south-west, in the bank to be formed in connection with widening the prism of the canal. It will consist chiefly of a breast wall built at the front edge of the bank, through which a sluice-way 3 feet square will be made, and from it a culvert of like dimensions will be carried to the rear line of the bank.

The breast wall will be 22 feet long, built upon a foundation of timber and plank, the top of which will be 17½ feet below surface water line, the wall to be 9½ feet thick at bottom, carried up plumb on both sides; but at 9 feet over the floor an offset of one foot will be made on the side next the bank, when it will be continued plumb to within five feet of the top; thence it will gradually diminish to the back line of the coping, which is to be 3½ feet wide and level with the top bank. On the north, on canal side of the breast, a triangular-shaped wing is to be carried up on each side of the sluice-way, to such a height as will be likely to keep the entrance to it clear.

On the canal side of the breast wall a range of sheet piles is to be sunk 4 feet below the bottom of the foundation timbers, to which they are to be spiked, and the trench cut for them filled with puddle.

The sides of the culvert to be of masonry 2½ feet thick, the inner faces to be made up of two courses of dressed stone, the covering stone to be 5 feet in length so as to extend one foot on to each of the side walls; they are to be dressed, properly jointed and laid close in full mortar beds. The whole to be laid on a foundation of timber and plank, placed so as to connect properly with the top of the 12-inch sill-course that forms the bottom part of the sluice-way. Two ranges of sheet piles, one of them ten feet from the breast wall and the other twenty feet from the same place, are to be put in so as to extend 3½ feet below the bottom timbers, 2½ beyond the side of the walls and stand 3½ feet over the top covering, and at each place a puddle wall 3 feet in thickness and of the full height of the piles is to be formed.

The culvert, after having been carried entirely through the bank at the level stated, must, at the outer end be made with such a descent as the position of the outlet will admit.

The face work and coping of the wings, the centre portion of the breast wall and the whole of the coping, the sides, sills and lintels of the sluice-way are all to be of dressed stone and masonry throughout laid in hydraulic cement mortar as described for the syphon culvert.

The sluice will be provided and placed by the canal officers.

Contractors should bear in mind that in carrying out the works connected with the culvert for the River St. Pierre, it is expected that everything possible should be done during the summer months towards effecting that object. The contractor will therefore be called upon to build the walls and a part of the trunk on both sides of the canal in the

summer and autumn of the present year (1876), and to make such arrangements as will enable the whole of the culvert to be built in the winter of 1876-7. The channels for the entrance and outlet of the river to and from the culvert will be paid for at the same rate per cubic yard for excavation as paid for the widening and deepening of the prism of the canal.

The removal of the old culvert, which is to be done after the new one is ready to be used, will be paid for by the cubic yard, including wells and trunk, stone work and timber or whatever may be necessary, and if the entire bottom part be taken out no deduction will be made for the water-ways, but if any part of the bottom is left in, the sectional area of the water-ways will be deducted.

The banks to be formed above and below the site of the old culvert, as well as over the new one, will be considered parts of those connected with the canal.

The inside faces of the banks or sides of channel are to be protected in some one or any two, or it may be partly in each of the three following ways as may be subsequently determined :—

1.—By a covering of pitched stone, of an approved class, laid at right angles to the face, on about twelve inches in depth of quarry waste or gravel. The pitched stone to be in regular courses, varying from *four* to *eight* inches in thickness, and from a depth of twenty two inches at the bottom part to a depth of sixteen inches at the top water line, laid throughout in coarse sand or fine gravel, and have the joints in the respective ranges properly broken over and with each other.

Where the bottom is clay or other material of that kind the first tier of stones is to be let in their full depth, in the position above mentioned, and laid so as to form a toe support to the wall. The whole of the stones to be well rammed and beaten down to a fair uniform surface.

2.—Making the inclination of the bank one-half horizontal to one vertical, and facing it with pitched stone 3 feet in depth at bottom, 2½ feet at the water line ; stone to be laid on a foot in depth of quarry refuse or gravel, and at right angles to the face, in regular courses 6 inches or more in thickness, one-third of the superficial area to be of stone the full depth of bed above stated, the other two-thirds may be made up of two stones.

The rear part of the first or lowest course to be let into the bottom, and on top the coping is to be laid horizontal 2½ feet in width and 9 inches thick, otherwise the top stones are to form a rounded edge if so directed.

The stones must in all cases bond properly over and with each other, and the whole be executed in a satisfactory and workmanlike manner.

3.—Constructing a wall 2½ feet wide on top, with a batter of 2 inches or more to the foot on the front side, and on the rear to increase 3 inches to the foot for the first five feet from the top, thence downwards they are to be plumb.

The wall must be built of an approved class of sound and durable, flat and well-shaped stones, not less than 6 inches thick, 2 feet or more in length, and have 3 feet area of bed at least, laid so as to form proper bond over and with each other in both front and rear ; the faces of the stones must be hammered or scabbled to a line corresponding to the position they are to occupy in the work.

Headers not more than 7 feet apart, and at least 3 feet depth of bed, are to be placed in each course.

The coping stone must be 2½ feet wide, fully 9 inches thick and not less than 3 feet long.

In rear of the walls a space of about 12 inches in width is to be made up with small stones or quarry waste, well rammed.

The foundation for the walls in either case to be sunk to 15½ feet below the surface water line of the canal, the sinking of which, below the water line of four feet under the top of the mitre, is to form a separate item.

Parties should bear in mind when tendering, that the black limestone, such as used for ordinary purposes in Montreal, will not be allowed on any part of the work connected with the section.

Contractors are requested to submit a price for each of these three different kinds of protection for the banks, subject to the distinct understanding that they provide, at their own cost, all the necessary materials, and that the work to be done may consist of all *three* kinds, or it may be of *two* of them, or wholly of *one* kind without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

For the purpose of enabling the deepening of the channel and the widening of it below the water line to be urged forward, the new culvert to be built and the present one removed, the side walls for the protection of the banks built, etc., the canal will be emptied, as nearly as circumstances will permit, in the early part of December, 1876, and the water allowed to remain out until the latter end of April, 1877.

In December, 1877, the water will be again drawn off, and the canal allowed to remain empty until the latter end of April, 1878.

The contractor's arrangements must therefore be such, and his operations be conducted in such a manner that the whole of the works on and connected with this section shall be done between the time of awarding the contract and the 25th day of April, 1878.

Contractors should bear in mind when "tendering" that a dam must be made at each end of the section, one at the upper end to prevent water passing on to or coming from Section No. 6, and one at the lower end to guard against water passing on to or coming from Section No. 4.

For the purpose of removing surface water, springs, leakage, snow, ice or any other accumulation of water from foundation of the culverts, foundations of side walls or at any other part on the section, sufficient pumping power must be provided and placed in the most advantageous positions to lift the water from foundations and other places as often as it may be necessary, and afterwards lift and discharge it into the River St. Pierre, or of disposing of it in some other way, without allowing it to pass on to the adjoining sections.

Contractors should also keep in view the fact that the respective bulk sums for unwatering the different parts of the works must embrace the construction of all dams, the providing and fitting up of all pumps and machinery that may be required for that purpose, also their full maintenance and removal when directed, as well as the replacing of them as often as it may be found necessary to fully carry out and complete all the

work herein described or connected with the enlargement of the canal as contemplated in this specification. It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundations of all structures on the section, must be embraced in the respective bulk sums stated in the tender.

PUDDLE,—wherever used, must be made of the best description of material for the purpose that can be obtained at any place on the section or within half a mile of the place where it is to be used. It is to be laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form a puddle bed or wall impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock," the former to embrace all kinds of material found in widening and deepening the channel or prism of the canal, forming foundation of culvert, by-wash, side walls, etc., except absolutely connected "quarry rock" and boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing, hauling and placing the material in spoil bank at the place, and in the manner herein stated, forming and grading towing path, berme bank, finishing up embankment in rear of culvert over by-wash, and doing everything connected with the excavation and banks on the section in a workmanlike and satisfactory manner, agreeably to the design contemplated in this specification.

But as the price per cubic yard of each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been executed and completed the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations for deepening the channel, or of the disposal of the excavated material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the intrepretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damages, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan contemplated in this specification, and the direction of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed working drawings, arranged, modified, and adapted to the locality, and for all such parts of the structures as may be required, will be furnished as the works proceed.

The contractor must provide, at his own cost and expense, all the service ground that may be required for the purpose of placing and preparing materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipments, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works, as herein described, and the instructions that may from time to time be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty fifth day of April, 1878.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 9th March, 1876.

APPENDIX No. 41.

LACHINE CANAL.

SPECIFICATION of the Work to be done on SECTIONS Nos. SIX and SEVEN of the Enlargement.

These two sections collectively are 10,000 feet in length and extend from Station No. 130, a point about 700 feet below Côte St. Paul Lock, to Station No. 230, as marked out on the ground and represented on the general plan exhibited.

They are to be let in one contract, and in this specification will therefore be dealt with as forming only one section, the works upon which consist chiefly in the enlargement of the channel above Station No. 146 to a mean width of *one hundred and fifty feet* and to a depth of *four* and *one-fifth* feet below the mitre sills of the present guard lock at Lachine; forming an inverted syphon culvert across under the canal; building piers and abutments for a swing bridge at Côte St. Paul; constructing a new lift lock at the latter place, and taking down the upper thirteen feet or more of the present lock and building it again with new face stone throughout; securing the lower part of the north wall; enlarging the channel below the lock to 200 feet mean width, etc., etc.

The water level of the different reaches is to be kept at the same height as at present and the foundation of all permanent structures, such as the new lock, bridge abutments and piers, syphon culvert, etc., are to be placed sufficiently low to afford a depth of water suited to fifteen feet in the reaches and fourteen feet on the mitre sills of the lock.

The new lock will be placed to the north of the existing one, and from the lower end of the section to Station No. 160 the excavation connected with the increased width of the channel will also be on the north side, thence upwards the widening will be done chiefly on the south side.

The side lines of the enlarged canal and the position of the respective structures will for the most part correspond with the lines shewn in red on the general plan exhibited. The Department of Public Works, however, reserves to itself the right of changing the

whole or any part of the line to such an extent as will admit of widening the channel wholly on either one side on the other, or of increasing the width on both sides, as may be subsequently determined; also of altering the position of any or all of the structures one hundred feet, either to the right or left, or of placing any or all of them two hundred feet or more, either upwards or downwards from that indicated on the plan, or in such other position as may be considered the most advantageous for the purpose contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The principal part of the excavation on this section will be clay, but part of it is of a hard nature; rock will however be found below the lock, at a height a little over the bottom line of the present canal, and at many places in the upper reach the surface of the rock is either at or a little below the level of the present bottom; but it generally underlies a hard class of material composed of clay, gravel and boulder stones firmly cemented together.

In rock cutting the side slopes are generally to be made *one-fourth* horizontal to one vertical, and in earth, or where vertical walls are to be built, the sides are to be made with as little slope as circumstances will admit. At other places the side slopes may vary from one-half horizontal to one vertical, or be made to an angle of forty five degrees; otherwise they may be made two horizontal to one vertical, or of any other inclination intermediate between the least and greatest slopes above mentioned, as may be directed.

The material excavated for both the widening and deepening of the prism of the canal, as well as that to be removed from the lock pit, foundations for bridge piers and abutments, culvert pit, etc., can all be deposited on the low land on the north side of the canal, between Stations Nos. 217 and 230, at the upper end of the section.

It will be observed from the situation of the work that a large proportion of the widening, and also those parts of the deepening in clay, can be done by machinery during the summer months, provided proper precautions are adopted to guard against interfering with the navigation. A large part of the excavation below Station No. 154 might also be carried to the spoil ground, by means of a tramway constructed in rear of the towing path.

Contractors will therefore be expected and required to provide the necessary equipment for carrying out the object in both these ways, so as to be fully prepared to move, haul, transport and elevate the material in such a manner as will enable it to be expeditiously taken to and deposited at the place above mentioned; unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way, in a more advantageous manner, within the time agreed upon for its completion.

If any of the adjoining proprietors are desirous of having their land raised to an extent that would render it more advantageous spoil ground than that above mentioned, the contractors, on receiving the sanction of the Department of Public Works, may use part of the excavated material for that purpose.

SPOIL BANKS—to be formed with approved uniform slopes, and must invariably be made of a regular height, and their tops have a declivity outwards from the canal.

TOWING PATHS.—At all places above the lift lock, where the widening of the prism is on the north side of the present channel, a towing path of the full width must be continued and formed, either as a whole or in part, as may be required. It is to be made 18 feet in width, and of a like elevation over the water line as the one now in use; at places where the bank in rear of it is of a greater height, a ditch 2½ feet wide at bottom must be cut, at the foot of the slope, towards which the top of the track-way shall have a declivity of one foot transversely.

The bottom of the ditch to have such an inclination as will carry the water freely to off-take drains, formed at such places as circumstances may require.

On the south side of the canal, if directed, a berme bank is to be left or formed, and in either case graded at a height of 18 feet over bottom, made 12 feet wide on top, with a declivity outwards to a catch-water drain cut where necessary, in rear of it, from which suitable cross drains are to be made as described for the towing path on the north side.

On the south side a roadway is to be graded by cutting at some places and forming a bank at others. It is to be made of such a width and height, and be drained in such a manner as the officer in charge may consider necessary for the accommodation of the public travel. The cost of making this road is to be embraced in the price for excavation.

SIDES TO BE TRIMMED.—The prism of the canal, as already stated, is to excavated to a mean width of 150 feet, *i.e.*, between the bottom and surface water level. This width is to be maintained on the upper reach, in both rock and clay excavation, and the slopes made to the respective inclinations before mentioned.

For the entire length of the section and width of the channel, the bottom above the fourth lock must be sunk to an uniform depth of four and one-fifth feet below the top of the mitre sills of the present guard lock at Lachine, and the bottom of the lower reach sunk four feet below the top of the lower mitre sill of the old fourth lock, or to a greater depth in both cases if rendered necessary by the thickness of the stratum of rock that has to be removed.

In the event of it being considered necessary to cut into the north bank at any place where it passes through or is immediately alongside of low ground, a new bank must be formed, or an additional width given to the present one, as circumstances may require.

In all such cases, the space to be occupied by the bank must be cleared of all stumps, roots and logs; all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the banks and seat prepared for them.

To render the banks at such places still more secure, as well as at any other place where the officer in charge may consider necessary, a trench from four to six feet in width, of such a depth and length as may be directed, is to be excavated at the front line, or in such other position, under the towing path, as may be subsequently determined, in which a puddle bank or wall is to be carried up to a foot or more over water line.

PUDDLE,—wherever used, must be made of the best description of material for the purpose that can be obtained at any place on the section, or within half a mile to the north or south of where it is to be used.

It is to be laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form a puddle bed or wall impervious to water.

There are to be only two classes or denominations of excavation recognized, namely: "earth" and "rock," the former to embrace all kinds of material found in widening and deepening the channel or prism of the canal above and below the fourth lock, forming the lock pit, foundation of piers and abutments for swing bridge, and for culvert, etc., except absolutely connected "quarry rock" and boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing, hauling and placing the material in spoil bank at the place, and in the manner herein described, forming and grading towing path, berme bank and road, finishing up embankment in rear of lock, bridge abutments and culvert, and doing everything connected with the excavation and banks on the section in a workmanlike and satisfactory manner, agreeably to the design contemplated in this specification.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that when the whole work shall have been executed and completed the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

It is to be clearly and fully understood that the whole of the work to be done on this section (numbered 6 and 7) for the deepening and enlarging of the canal, will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all those parts of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks,) at short distances apart, along the whole length and breadth of that part of the present canal within the boundaries of the section. A duplicate copy of the cross-sections, made from these levels and soundings will remain on record in the office of the Department of Public Works, another in the office of the Resident Engineer, and from these, together with levels and soundings taken after the whole shall have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

Lock—to be 270 feet in length between the gate quoins, 45 feet in width between the side walls at bottom; it will be placed on the north side of the present lock, and will be so situated that the longitudinal centre lines through the respective structures will be 78 feet apart opposite the upper quoins, and 81 feet apart opposite the lower quoins of the old lock, and the transverse range of the upper gate quoins will be about the same in both locks, hence the lower quoins of the old lock will be 70 feet west of those in the new structure. A retaining wall, about 85 feet in length, must therefore be built in continuation eastward of the north wall of the present lock, which, at its lower end, will be connected with the lower south wing wall of the new lock.

The north upper wing wall of the present structure is to be connected with the south upper wing wall of the new one by means of a circular wall, as represented on the plan.

The walls of the old lock, being in a ruinous condition, are to be taken down to fully two feet below the surface of the lower reach, or to such other depth as may be required, and the walls are again to be built up with an entirely new and better kind of face stone.

All the walls above referred to, with the exception of those directly connected with the present navigation, are to be commenced at a depth that can be adapted to vessels drawing 14 feet of water passing through the canal, otherwise the bottom and mitre sills of the new lock, as well as the retaining wall and wing walls, are respectively to be *five feet lower* than those of the lock now in use.

The faces of the new structure and of all the walls above mentioned are to be of the best description of properly-dressed gray limestone, backed up with large-sized, flat-bedded stones of an approved kind, laid throughout in hydraulic cement mortar, and placed on a foundation of timber and plank, prepared and arranged as herein described.

Parties tendering should bear in mind that the leaky and defective state of the present lock renders it indispensable that the upper 13 feet at least of both walls should be taken down, new walls built, the lower part of the north wall secured, and the retaining wall at the lower end of it constructed before the foundation pit for the new lock can be excavated to the proper depth or laid dry.

When the works above mentioned have been completed as described further on in this specification, the excavation of the bottom part of the lock pit can then be proceeded with in the usual manner. It is to be made of suitable dimensions to admit the side and wing walls, and to correspond with the lines marked out and the levels given by the officer in charge; great care must, however, be taken not to disturb the narrow bank between the north wall of the old lock and the pit. On this, the south side, a slope of one-half horizontal to one vertical will be allowed, and on the north side and ends, an allowance of one to one will in each case be made for a slope.

The bottom must be made smooth and level at the proper height to afford throughout an uniform bearing for the foundation timbers, which are to be laid transversely and covered with three-inch pine plank, to form a protection for the bottom and a bearing surface for the walls.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where the lock is to be built, the walls will be commenced upon it; but if the rock is unsound or the fissures in it numerous, or the strata be thin or irregular, a floor of pine timber, covered with three-inch pine plank, will be laid, as provided for a foundation on earth or clay.

The material excavated from the lock pit, if of an unsuitable kind or not required for the purpose of making up the banks, must be hauled to and deposited on the spoil ground near the upper end of the section, as described for that taken from the reaches and other parts of the work.

The bottom to be sunk and the foundation timbers laid at such a depth that there will be 14 feet water on the mitre sills, and $15\frac{1}{12}$ feet water on the top of the first course of floor plank when the lower reach is at its proper height.

FOUNDATION TIMBERS—to be of pine 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up the distance, one of which must, however, extend from the rear line of one wall across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 6 inches apart through the chamber, above the upper mitre sill, and at the lower end of the lock, and must rest uniformly throughout their entire length on the bottom, and on mud sills placed under the walls. The spaces between them must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; or if directed, the spaces, and at the ends of the timbers, must be made up with concrete, their tops must be dubbed to an uniform surface, to afford a fair bearing for the planking. The timbers, before being laid, must be counterhewn, if so directed.

MUD SILLS.—Two ranges of mud sills are to be placed longitudinally under each of the side walls. They are to be of pine timber, 12 inches square, arranged in trenches cut for their reception, and laid so that their tops shall be on the same level as other parts of the foundation. The spaces alongside of them must be well filled with puddle, and also a space of 4 inches between the ends of the respective pieces; they are not to pass through the sheet piles, but must be left 6 inches short on each side, which space is to be filled with puddle or concrete as may be required.

MITRE SILL PLATFORM—to be 14 feet in width, made up of timbers 12 inches square and of a length to reach from rear to rear of walls, all of which must be counterhewn and well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts ($1\frac{1}{2}$ inches in diameter), passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts passing through and secured to anchor timbers laid at the bottom of the sheet pile trenches, or to a block of masonry built for that purpose.

The joints throughout must be well caulked with at least two threads of cakum, and every precaution adopted to render the whole water-tight.

PUDDLE TRENCHES, ETC.—Five or more trenches are to be cut across the foundation for the reception of sheet piles, namely: one at the upper side, another at the lower side of each of the mitre sill platforms, and one at the lower end of the lock. They are to be sunk 5 feet below the foundation timbers, and are not to exceed $2\frac{1}{2}$ feet in width. One side of each trench must be cut plumb and smooth, so as to afford an even bearing to the piles for their entire depth.

After the anchor walls are built, or anchor timbers arranged, and the piles placed, the trenches must be well filled with puddle to the height of the adjoining ground.

The puddle must in all cases be made of the best material for that purpose which can be obtained within one mile of the work, and must be cut, mixed, prepared and laid as directed by the officer in charge. Ranges of sheet piles are also to be placed in the foundation of the chamber if so directed.

SHEET PILES—to be of 4-inch pine plank, placed close vertically, generally 6 feet long; they are to be jointed with a plane, and the edge of each plank chamfered on the side next the trench. When placed, they are to be fastened to the platform timber with 8-inch pressed spikes, two through the top of each plank.

FLOORING—to consist of two courses of pine plank; the first 3 inches in thickness, is to extend over the whole area of the foundation; and the second course, 2 inches thick, is to be laid between the side walls in the chamber and at both ends of the lock. They are all to be jointed with a plane, and when being laid must be driven up with wedges to water-tight joints; every 3 feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must, in all cases, break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and $1\frac{1}{2}$ inch diameter, two in each end of a plank, and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid; the latter to be fastened with pressed spikes, two at each end of a plank, and one at each crossing of a timber, on alternate sides of the plank.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned, and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 16 inches when dressed. The mitre sills are to be 19 x 19 inches, checked 3 inches into the platform timbers, and are to be tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check, 3 inches deep, is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking.

Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and when about to be placed in their berths, a strip of canvas, well saturated in boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, 3½ inches wide and five-eighths (⅝) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be 2 feet 4 inches long, one inch and a half (1½″) diameter, have upset heads, and be well ragged at the point.

If the foundation is rock, the mitre sill platforms will be made as above described—laid in a full bed of mortar, and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATERS.—Where the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock, 4 inches or more in depth, and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timber of the platform.

Before the stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check; the upper timber must also be imbedded in white lead, and the whole secured to the rock with fox and key-bolts, 1¼ inches diameter, placed not more than 10 feet apart.

Stop-waters similar to those above described are to be placed at the upper sides of the recesses of the locks where the foundation is rock.

In other parts of the recesses than those occupied by the platform, there are to be timbers, 12 inches square, laid 6 inches apart; also for a distance of 12 feet below the lower side of the platform, and to the upper end of the wing walls, at the head of the lock.

These timbers are to be laid level, scribed to the rock underneath, or laid on a bed of fine concrete, as the case may require, and each one of them fastened by means of two fox-wedged bolts, 1¼ inches diameter, passing at least 9 inches into the rock.

The spaces between them are afterwards to be filled with concrete, and their upper sides dubbed to a fair surface for the planking.

If found necessary to lay timbers in the chamber of the lock on a rock foundation, they are to be placed 12 inches apart, and the spaces between them filled with concrete.

MASONRY.—The lock is to be 8 feet 8 inches lift, and the side walls carried up to 2 feet over the surface water level of the upper reach, or to the height of 25 feet 10 inches over the floor.

The chamber and recess walls are to be 9½ feet wide at the bottom, with counterforts in rear, 6 feet long—in line of wall—and 3 feet projection, and placed not more than 12 feet apart. The recesses for the gates are to be made 2 feet 8 inches deep at top.

The face of the chamber and wings is, throughout, to have a batter of *one* in *twenty four;* but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 25 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top; thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the lock must be of approved, sound and durable stones; those forming the face work must be of the best class of gray limestone, free from drys, seams or other defects, and must be at least equal, in every respect, to the best of the stones used in the present guard lock at Lachine.

The face stones must be of an uniform texture and color, and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height—the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stones exceeds 18 inches in height, the face of the chamber may be made up of two courses of stone of equal height.

From the lower end of the lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths of an inch.

The chamber walls, between the points above mentioned, are to be faced with a good description of coursed, boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths of an inch.

CUT STONES—to be neatly dressed and boucharded; made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel, and their end joints in all cases kept full for at least two-thirds the depth of the beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall, and not less than two and three feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face and 4½ feet depth of bed, placed not more than eleven (11) feet apart from centre to centre. The headers in each course are to be arranged, as nearly as possible, mid-way between those in the course immediately below.

No two vertical joints, in adjoining courses, are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is also properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{4}$ times their height; and in all cases the tail of a header must have a width of two-thirds ($\frac{2}{3}$) the length of its face.

HOLLOW QUOINS—to be alternately headers and stretchers, the former at least $4\frac{1}{2}$ feet face and $5\frac{1}{2}$ feet depth of bed; the latter $5\frac{1}{2}$ feet face and $4\frac{1}{2}$ feet bed in the top courses, increasing in dimensions downwards at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

RECESS QUOINS—to be also $4\frac{1}{2}$ by $5\frac{1}{2}$ feet, and $5\frac{1}{2}$ by $4\frac{1}{2}$ feet, laid alternately out-bond and in-bond, bevelled as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

CHAIN WELLS AND MAN-HOLES.—There are to be eight chain wells in the position indicated on the plan; each well will be two feet square inside; and the man-holes from them to the front of the lock walls, are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone, sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain, when slack, lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man-holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face of the walls of the recess, and are to be properly bonded over and with each other at the angles.

CHECKS.—For the reception of stop-water timbers, two checks are to be formed in the face of the wings at both ends of the lock; they are to be arranged as shown on the plan, be 2 feet apart, 12 inches wide, and 6 inches deep at the top, and made plumb in the rear.

COURSED WORK,—for the face of the chamber walls, may be 9 inches high and upwards; but a course once commenced must be continued the same height throughout, and in no case will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded, and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed three-eighths of an inch.

BACKING—to be of an approved class of large well-shaped stones, not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds, and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face-work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick; but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall. The black limestone, used for ordinary building purposes in Montreal, will not be allowed in the work.

COPING STONES—of the chamber, recesses and wing walls, are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The hollow quoin coping must, however, be at least $6\frac{1}{2}$ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full; the upper bed and face neatly dressed, and the inner top arris rounded off to a radius of 3 inches. The whole to be laid so that the horizontal and vertical joints shall not exceed $\frac{1}{4}$ of an inch.

A dowel, 4 inches long, of $1\frac{1}{2}$-inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

The descent from the coping of the lock to that of the bank below it on the north west side is to be made by means of a range of steps, 4 feet in width, cut out of the solid; the rise of each not to exceed 9 inches, and the treads to have an uniform width of 12 inches. They are to be arranged, placed and secured in like manner as those at the lower end on the east side of the second lock.

BREAST WALL—will be carried up to within 6 inches of the bottom of the upper reach, unconnected with the side walls of the lock; it will be of coursed masonry 7 feet wide at bottom, plumb in the rear and on the lower side, battered to a width of 5 feet at the top, and then covered with large flat-bedded, scabbled and well-jointed coping stones.

MORTAR.—The whole masonry of the lock and other structures to be described must be laid in mortar, made of the best hydraulic cement, mixed with clean

large-grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them; and in warm weather the beds and joints of the stones must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

RETAINING WALL.—The seat for the wall below the present lock, and opposite the lower recess of the new structure, is to be sunk to an uniform depth of 6 feet below the top of the lower mitre sill of the old lock if the foundation is of sound durable rock; but if otherwise, or the bottom is of clay, it will sunk to 7 feet below the top of the mitre sill, and a foundation of timber and plank laid as a bearing surface for the wall.

The timbers are to be of pine 12 inches square, counterhewn and laid longitudinally in five continuous ranges about 9 inches apart, in such a manner as to rest uniformly on the bottom throughout the entire length, and so that no two joints on adjoining ranges shall be nearer than 6 feet to each other. The spaces between them must be well filled with concrete, or otherwise, as may be directed. The top of the timbers, when laid, must be dubbed to an uniform surface to receive the covering, which is to consist of 3-inch pine plank, laid obliquely to close joints, and be secured with 7-inch pressed spikes.

Provision to be made for carrying up counterforts in the rear, by placing in the position they are to occupy, in each case, two sill pieces, laid so as to receive the covering plank.

The wall is to be 9½ feet thick at bottom, with counterforts in rear 6 feet long in line of wall and 3 feet projection, and placed not more than 12 feet apart; it is to have a batter of *one* in *twenty-four* on the face, and the back is to be carried up plumb to within five feet of the top, where the counterforts are to terminate and a continuous, regular, inclined, smooth frost batter formed up to the top rear line of coping.

The coping to be four feet wide on top, and in all other respects the materials used in the wall must be of like dimensions and of a similar class, and the workmanship throughout executed in like manner as described for the cut stone masonry portion of the lock.

Where the wall connects with the lower part of that of the present lock, the stones of the new work are to be bonded into those of the old, or such other course adopted as circumstances may require and as may be directed when the building operations are in progress.

At the lower end the wall is to be made circular, and connected with the lower wing of the new lock, as indicated on plan.

The circular wall that connects the adjoining side walls of the two locks at their upper ends is to be faced with cut stone, and the foundation for it is to be formed of timber and plank, as described for the retaining wall below the old lock.

As previously stated, the walls of the present lock are to be taken down to at least two feet below the surface level of the lower reach; when doing so, all those stones that the officer in charge may consider fit for backing are to be piled or placed on the most suitable and convenient ground in the vicinity that can be obtained by the contractor, who must, for this and all other purposes connected with the works, provide his own service ground. The refuse material, or such as has been decided as unsuitable for use in the walls are to be hauled to the spoil bank at the upper end of the section, or otherwise disposed of in such a manner as the Department of Public Works may approve. The taking down of the walls and depositing the material as above stated will be paid for by the cubic yard of wall removed. All the stone suitable for backing, taken out of the walls of the old lock, may be used in the new work.

The face work must, as already stated, be wholly of approved gray limestone, of the dimensions and prepared as described for the new lock. It is, however, to be adapted and arranged to suit the openings, quoins and piers of the present structure.

The breast and curved walls at the upper end of the lock are to be overhauled, and such new stone furnished for them, and such repairs made as may be required.

The north lower wing of the lock, or as much of it as projects beyond the rear line of the side walls, must be wholly removed to admit of making a water-tight connection between the back or end of the centre retaining wall and a range of concrete to be formed in rear of the north side of the lock for its entire length.

The seat for this concrete wall must be formed immediately along by the back of the old lock wall, and sunk to the full depth of the foundation of the new structure, or 5 feet below the present lock. Great care must be taken to clean the back of the old wall for the whole distance and height, as the concrete wall (3 feet in width), is to be carried up to at least 18 inches over the line between the old and new portions of the works.

The removal of that portion of the old structure above mentioned, together with building new walls and constructing the centre retaining wall previously described, must be done between the close of navigation in December and the twenty fifth day of April in the following spring, on the contractors being notified by the Department of Public Works to that effect in the early part of November preceding.

Côte St. Paul Road Bridge.—The works to be done on this section embrace the construction of piers and abutments for a swing bridge intended to take the place of the present means of crossing the canal at Côte St. Paul Village. The removal of the piers, etc., of the old structure, in the manner and at the time directed, is also included.

The water-way is to be in *four* divisions, the two centre ones of which are each to be 46 feet wide and form the navigable channels. The piers and abutments are to be of masonry, laid in hydraulic cement mortar; built chiefly in the form, of the dimensions, and in the manner herein described, or as may be subsequently directed.

In the vicinity of where the bridge piers and abutments are situated, a space of 190 feet in length and 180 feet in width is to be sunk to the depth of fifteen feet below water level, and the sides are to be made to a slope of one horizontal to one vertical.

The material excavated from this space, as well as from the seats of the piers, which are 2 feet 3 inches lower, or 17¼ feet below water level, must be hauled to near the upper end of the section, and deposited there, on the spoil ground previously mentioned.

The centre and rest piers of the bridge are to be parallel to the centre line of the canal; the former to be 18 feet square and the latter 18 feet long by 9 feet thick at top. Through each of them an arched culvert 8 feet in width and about 8 feet in height is to be made, on a line ranging with that of the canal.

They are to be built on a foundation of timber and plank, the top of which must be at least 15¾ feet below canal surface, and in each case they are on all sides to have a batter of one in twenty four.

The arch stones of the culverts are to be 21 inches deep, and dressed to radiate truly for their full depth, and made to lay throughout to joints of one-fourth (¼) of an inch. The bottom of the arch or water-way is to be of dressed and properly-jointed stones of a size that two of them will make up the width of the opening and at each end pass 15 inches under the wall, the second course to project one foot into the opening, and the third course 6 inches.

The face stones of the piers to be 2 and 3 feet depth of bed in the alternate courses, with headers in every course 4½ feet long, placed not more than nine feet apart from centre to centre. The beds and ends of the stones are to be kept full and dressed so as to lay to joints one-fourth (¼) of an inch, and have the face in all cases picked or scabbled to a fair surface; this is understood to be applicable to all the four sides of the centre as well as the rest piers.

The heart of the wall in each case to be made up with flat-bedded stones, not less than 4 feet area of bed, and of the full height of the face stones; their beds and joints must be scabbled or picked, if necessary, so that when laid the horizontal joints shall not exceed five-eighths (⅝) of an inch, and the vertical joints not be more than one inch and a quarter.

The piers to form the seat of the swing portion of the bridge when in position are to be 10½ feet thick at bottom, the sides of which are to be parallel to the canal, and the ends be at right angles to the face of the pier. They are to be faced on both sides, and throughout be of a like class of material and workmanship, and the foundation for them be formed at a like depth as described for the centre and rest piers; both sides and ends are to have a batter of one in twenty four.

At 4 feet from the top of these piers, or at such other height as may be required, offsets on the front side are to be formed for the bridge seat.

The abutments are to be of masonry placed 30 feet or more from the piers for the bridge seat, and the foundation for them laid at 12 feet below surface water line, or at such other level above or below that point as circumstances may require. They are to be

7½ feet or more in thickness, carried up to a batter of 1 in 12 on the face to the water line, and made plumb in the rear to within 4 feet of the top, thence the wall will diminish to the rear line of the coping, which will be 3½ feet in width. The face work to be similar to that described for the piers, and the backing of large-sized well-shaped stones, laid level in full mortar and properly bonded throughout the wall.

The centre piers, piers for seat and rest of bridge, as well as the abutments, must all be built of an approved class of stone, free from drys, seams and other defects, laid in hydraulic cement mortar, be properly bonded throughout, and have all the vertical joints well grouted as the work proceeds.

Coping stones on all the piers to be at least 15 inches in depth, of a size that two stones will make up the width of the piers for the seats and rests of the bridge, and break joint properly with the adjoining stones. Those on the centre pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers of the turntable. They must be full bedded throughout, and dressed so as to lay to joints not exceeding ¼ of an inch; and the top side must have a fair surface, neatly boucharded, and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed, the space between it and the outer range of coping must be filled in with stone of the same thickness as the latter, properly dressed and jointed, to the width, and be at least 3½ feet in length.

In the centre of the rest piers, one of the coping stones, for a width of 4 feet, is to be 24 inches in depth, and checked to the curve of the toe of the bridge. This stone in each case must be secured with fox-wedged bolts 1½ inches diameter, let into the masonry underneath.

The coping on the piers for the seat and the abutments of the road bridge, will be 10 inches in thickness at the centre of the road, curved on top so as to be 8 inches at the sides, placed so as to form a recess for fixed girders and the toe of the swing.

At all four corners of the bridge, parapet piers are to be built 4½ feet square at base, diminishing upward—one of which at each end of the bridge must be recessed and hollowed out to receive machinery.

The wings of the abutments are also to be carried up to the same height as the parapet piers, and finished with coping, as indicated on the plans.

The foundation timbers to be of pine, laid level, and must have an uniform bearing throughout their entire length. Those under the centre and rest piers are to be laid transversely to the canal, one foot apart, and for the other piers and abutments, they are to be laid longitudinally or transversely as may be required.

In all cases the spaces between the timbers must be filled with a good description of puddle or concrete as may be directed.

The covering plank to be of pine, 3 inches thick, laid obliquely, and fastened to the timbers with 1¼-inch white oak treenails 8 inches long.

SHEET PILES—of 4-inch pine plank are to be put in or driven on all sides of the piers if the officer in charge considers it necessary.

FENDERS—are to be constructed on both sides of the channel ways, extending for some distance above and below the bridge, as represented on general plan. Those in connection with the seat piers for the toe of the swing are to be formed by means of piles, caps, braces and wale pieces, all of white oak timber. The piles are not be less than 12 inches diameter at the small end, driven from 6 to 10 feet into the bottom, and be about 6 feet apart; at the anchor timber two piles will be driven on the line of the fenders and one about the middle of each tie timber. The fenders proper are to be formed of two pieces each 8 x 12 inches of white oak, kept two inches apart by means of white oak blocks 9 x 12 x 2 inches, placed vertically 6 feet apart from centre to centre. The different pieces in each range are to be connected by means of double oblique joints, let three inches or more into and on to each other respectively. The joints in the inner range must be at least 12 feet on either side of those on the outside. They are to be fastened to the piles with bolts one inch diameter and also to the centre cribs subsequently described, in both cases they are to be put on and secured in such a manner as may be directed.

In case that piles cannot be driven sufficiently into the bottom to form the necessary fenders for the bridge, framed bents of white oak timber, 12 x 12 inches, may be used for that purpose. To enable the latter plan to be carried out, a trench must be cut 18 feet below water line for the reception of sills, into which the posts of the bents are to be securely fastened.

At the bottom of canal, and at such a height over it as directed, the posts are to be connected with horizontal ties; and both longitudinally and transversely ranges of diagonal braces are to be framed vertically in between them and well secured with straps and bolts.

At top the posts are to be connected with caps, ties and wale pieces, framed, bolted and secured as previously described.

CRIB WORK.—Between the centre and rest piers, as well as above and below them, and if directed, above and below the piers for the seat of the bridge, crib-work is to be constructed to form bearings for the fenders and for the protection of the respective parts of the work.

The cribs for the middle portion of the work are to be the same width as the stone piers, *i.e.*, 18 feet wide at top, increasing downwards on both sides at the rate of one in twenty four, and through the middle of them, longitudinally, a clear water-way of such dimensions must be formed as may be directed.

Transverse openings are also to be made in the crib work adjoining the centre and rest piers and elsewhere of such shape and dimensions as may, together with the centre openings, give an area equal to at least that of the archways formed through the masonry.

In the crib work above and below the piers for the seat of the bridge there are, in each case, to be left two openings on the upper and two on the lower side. The sides of these openings are to be formed, framed and secured in like manner as the face work of ends of the cribs. The bottom to be of 3-inch plank, well fastened with pressed spike, and the top to be formed of pieces not less than 10 inches thick and of the length to take a full bearing on the side timbers of the respective water-ways.

The cribs are to be of pine timber 12 inches square, straight, sound, full on the edges and are to be framed so as to leave a space of $1\frac{1}{2}$ inches between the different courses. At the angles they are to be connected by double-bevelled dovetails, arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be simi-

larly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and $\frac{5}{8}$ inch diameter is to be driven through the dovetail.

CROSS TIES—to be at least 10 inches thick, of sufficient size to square 10 x 12 inches at both ends, and of the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart, and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the course immediately below and above.

Their ends are to be dovetailed $3\frac{1}{2}$ inches into the timbers under and over them, the dovetail to splay $1\frac{1}{2}$ inches on both sides so as to stand 8 inches at the neck and 11 inches at the outer end.

Under the head of each tie, at the joint between the courses immediately below it, a block $1\frac{1}{2}$ x 12 x 12 inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, $\frac{7}{8}$ of an inch diameter, is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it and into the head of the next cross tie.

LONGITUDINAL TIES.—At such places in the cribs as may be required, longitudinal ties, 10 inches thick, are to be framed into and dovetailed between the end timbers, have blocks under them and be secured by bolts of similar dimensions and in like manner as described for the transverse ties, into which they are to be notched and fastened at the crossings by means of white oak treenails, 2 inches diameter.

The cribs are to be further secured by vertical ranges of plank placed inside, and extending from the lowest side timber up to the water line. There are to be three ranges on a side, that is to say: One at or near each angle and another in the centre, making in all six vertical ranges in a crib. The planks are to be 4 inches thick and 10 inches in width, fastened from the inside with 10-inch spike, five-eighths of an inch diameter, two driven through each plank into each of the lowest side pieces, and one at every crossing of a side timber from the bottom timber upward. They may be put on in lengths of from 8 to 10 feet or more; but they must be so arranged that the upper length in all cases shall reach down at least two feet lower than the top of the plank of the same range below.

In the first course of side timbers, the cross ties are to be placed not more than 3 feet apart, so as to obviate the necessity of using floor timbers.

The cribs forming the upper and lower terminations of the piers are in all cases to splay five feet or more on the side next the channel.

The whole interior of the crib work except the water-ways to be filled with an approved class of moderate-sized stone ballast.

For the protection of the structure and guide piers, three clusters of piles are to be driven within range of the centre pier, at suitable distances above and below it; they are to be connected by means of thorough-bolts, straps, etc., and stand one foot or more over the cap-pieces, as may be required. Piles are also to be driven for the protection of the framed bents or crib work placed above and below the seat piers of the bridge.

The superstructure of the bridge, both for the fixed and movable parts, as well as the machinery for working the latter, will be made a separate contract.

CULVERT.—At a point between Stations Nos. 159 and 162, an inverted syphon culvert (five feet wide and four feet high inside), of masonry, arched on top, is to be constructed across under the canal on a bearing surface of timber and plank.

THE PIT—for it will be 240 feet in length, 17 feet of which at the south end and 24 feet at the north end must be made 20 feet wide, and at other places it is to be 14 feet wide at bottom; the whole to be excavated to an uniform level surface at the depth of 24 feet below the top water line of the canal. The sides to be made as nearly vertical as the nature of the material to be removed will admit; but as the contractor must assume the risk and expense of removing all slides that occur, he will be allowed a slope of two horizontal to one vertical for those parts of the pit outside of the present canal, and a slope of three horizontal to one vertical for all other parts of the pits in clay cutting.

FOUNDATION TIMBERS—to be pine 12 inches square, laid 6 inches apart transversely to the culvert or parallel to the canal; the spaces between them and at their ends must, immediately after they are satisfactorily laid, be well filled with the best description of puddle, well cut and rammed; or, if so directed, concrete must be used for that purpose.

Four ranges of sheet piles of 4-inch well-jointed pine plank, 6 feet in length, are to be put in across the foundation, and extend 3 feet on each side beyond the line of the walls—one at the inner side of the well at both ends of the culvert, and one immediately under the toe of the slope of the bank on both sides of the canal.

Trenches are to be cut for the sheet piles, of such a depth as may be directed, and the spaces must afterwards be filled with puddle.

The sheet piles having been properly prepared, and placed in their position, they are to be fastened to a long floor timber laid for that purpose; the puddle to be selected, made and put in as described for similar work in the lock foundation.

The floor timbers must then be dubbed to an uniform surface to receive the plank, the lowest tier of which is to be three inches thick, well jointed with a plane, laid so as to break joints; be driven up close and fastened with treenails in like manner as stated for the first course of plank in the lock. The top of the lower tier must, if necessary, be dubbed before the laying of the second tier is commenced, which is to be two inches thick, laid close within the side walls, and so as to break joints throughout, and be fastened with pressed spikes.

MASONRY.—The water-way of the culvert is to be five feet in width between the side walls or abutments, which are to be twenty inches high to the springing line of the semi-circular arch that forms the lower side of the top covering. The abutments are to be four feet thick, carried up to a batter of one in twelve on the outer side, to within 9 inches of the crown of the arch. All the face-work of the water-way and wells at both ends connected with it must be of boucharded or dressed stone, and the masonry throughout be of a like class of workmanship and of material, laid in full beds of hydraulic cement mortar, as described for the lock.

The face stones of the side walls must be of the full height (20 inches) and not less than two feet in width, their beds and end joints must be full and have their arrises kept good; arch stones to be 18 inches deep and dressed to radiate truly for their full depth and so that both they and the abutment stones will lay to joints not exceeding one-fourth ($\frac{1}{4}$) of an inch.

The well at the south end to be 5 feet wide and 6 feet long. Breast wall to be 5 feet thick at bottom, carried up plumb on both sides to within 4 feet of the bottom of the water-course, where a frost batter will be commenced on the south side, and carried up with such an inclination as to terminate at the rear line of the coping, which is to be 3½ feet in width, and of a length to extend at least one foot into the wall on each side.

The wall immediately over the southern end of the arch, and also the side walls, are to be six feet in thickness, and that part of each of them next the well is to be of dressed stone, properly bonded at the angles and over each other. They are to be carried up plumb on the face to the under side of the coping, and the rear sides of them are also to be made vertical up to within five feet of the top bank or adjoining ground, where a frost batter is to be made with such an inclination as will strike a line 2½ feet back from the respective sides of the well, at or near the surface of the ground.

From the point above mentioned upward, the walls are to be 2½ feet in thickness, faced on both sides, and must be made up of stones the full width (2½ feet), to the under side of the coping, which is to be three feet wide on top, project three inches on each side, and have the top dressed so as to be one inch higher, for a width of 9 inches in the middle, than on either face.

The top of the side walls to have an inclination outwards of about one and a half horizontal to one vertical, except immediately over the breast wall, where the coping is to be level.

The side walls and retaining wall at the outlet on the north side will be similar to those above described, but, instead of a breast wall, the bottom is to have a slope upwards of about two horizontal to one vertical, and be formed of pitched stone laid in cement mortar and made 18 inches lower in the middle than at the sides.

The faces of the banks at both ends of the culvert, for a distance of 25 to 35 feet, or for such other distance as may be required, are to be protected by pitched stone laid dry, or in such other way as may be subsequently determined.

A foot in depth of concrete is to be laid over the top of the culvert, and the entire space between the side walls and the bank, as well as over the top of the concrete, is to be made up with the best description of puddle, otherwise it must be prepared and made for such other width and extent as may be directed.

In case rock is found in the culvert pit, the bottom must nevertheless be sunk to the depth previously stated, unless the surface is nearly level at a suitable height and the rock is of a compact nature, when a timber bottom may be dispensed with, and concrete be used in rear of the walls instead of puddle.

When making up the embankments at and over the ends of the culvert, at the bridge abutments, in rear of the lock walls and between the lock and Station No. 157, and at all such places where a bank is to be formed through or alongside of ground that is lower than the canal surface, or *wheresoever a water-tight bank is required, the material must be hauled on to the respective banks in carts or waggons and laid on in layers not exceeding one foot in depth at a time,* and if the work be done at a dry season of the year, water must be thrown over each layer to assist in consolidating the material.

Before forming the new bank between Stations Nos. 144 and 152, the contractor must make such arrangements as will fully guard against any interruption to the public travel on what is known as Côte St. Paul Road. For this purpose a new line of road connecting with the present one at a point opposite Station No. 145, and with the swing

bridge must be formed, graded and macadamized in a manner and to such an extent as circumstances may require. The material taken from the excavation may be used for filling, levelling or otherwise making up the road-bed, but the price tendered for road formation must cover the entire cost of such ditches, drains, culverts and all other expenses connected with changing the line of road, except macadamizing it, which will be paid for by the cubic yard.

The price tendered for this part of the work must include procuring, hauling, breaking and spreading the best description of stone for that purpose, also the cost of compressing the metal after it has been laid, by means of a heavy roller drawn over it a sufficient number of times to render it at once suitably serviceable for public travel.

The *By-wash*, situated on the north side of the canal at a place nearly mid-way between the lock and bridge at Côte St. Paul, is to be taken down and the stones in it considered suitable for use in the new work are to be piled up at such places in the vicinity where the contractor may have secured a right to service ground for that purpose, the refuse material is to be taken to the spoil ground at the upper end of the section, or be otherwise disposed of in such a way as may be approved of by the Department of Public Works.

In case a new structure is built for a like purpose as the present one, it will be placed a short distance further to the north-west, in the bank to be formed in connection with widening the prism of the canal. It will consist chiefly of a breast wall built at the front edge of the bank, through which a sluice-way 3 feet square will be made, and from it a culvert of like dimensions will be carried to the rear line of the bank.

The breast wall will be 22 feet long, built upon a foundation of timber and plank, the top of which must be 17½ feet below surface water line, the wall to be 9½ feet thick at bottom, carried up plumb on both sides, but at 9 feet over the floor an offset of one foot will be made on the side next the bank, when it will be continued plumb to within five feet of top, thence it will gradually diminish to the back line of the coping, which is to be 3½ feet wide and level with the top bank. On the south, on canal side of the breast, a triangular-shaped wing is to be carried up on each side of the sluice-way to such a height as will be likely to keep the entrance to it clear.

On the canal side of the breast wall a range of sheet piles is to be sunk 4 feet below the bottom of the foundation timbers, to which they are to be spiked and the trench cut for them filled with puddle.

The sides of the culvert to be of masonry 2½ feet thick, the inner faces to be made up of two courses of dressed stone, the covering stone to be 5 feet in length so as to extend one foot on to each of the side walls; they are to be dressed, properly jointed and laid close in full mortar beds. The whole to be laid on a foundation of timber and plank placed so as to connect properly with the top of the 12-inch sill course that forms the bottom part of the sluice-way. Two ranges of sheet piles, one of them ten feet from the breast wall and the other twenty feet from the same place, are to be put in so as to extend 3½ feet below the bottom timbers, 3½ beyond the side of the walls and stand 3½ feet over the top covering, and at each place a puddle wall 3 feet in thickness and of the full height of the piles is to be formed.

The culvert, after having been carried entirely through the bank at the level stated, must, at the outer end, be made with such a descent as the position of the outlet will admit.

The face work and coping of the wings, the centre portion of the breast wall and the whole of the coping, the sides, sills and lintels of the sluice-way are all to be of dressed

stone and the masonry throughout laid in hydraulic cement mortar, as described for the lock.

The sluice will be provided and placed by the canal officers.

Where the surface of the rock is not more than 7 feet below the water line, the face of the bank is to be protected by a dry wall built of large well-shaped stones of the best class that can be found at any place in the spoil banks between the upper end of section No. 8 and Lachine, or at any other place where the contractor can obtain suitable stones. It is to be two feet wide on top, increasing downward on the face at the rate of 2 inches to the foot, the back to be plumb and the coping stones to be of the full width of the wall (2 feet) are to be, when laid, one foot below the top bank. All the stones must be well bonded over and with each other, and the face of the wall made to range with the general line of the canal. In rear of these walls, if so directed, a space of 12 inches in width is to be made up for such a height as may be requested, with small stones, quarry waste or gravel, well rammed.

Where the surface of the rock exceeds a depth of 7 feet below the water line, the inside faces of the banks are to be protected in some one or in any two, or it may be partly in each of the three following ways, as may be subsequently determined :—

1.—By a wall or covering of hand-placed "rip-rap" stone, varying from thirty two inches in depth at bottom to twenty inches in depth at top. The stones not to be of greater dimensions than can pass in every way through a square eight inches on the sides, except the bottom tiers, which are to be larger, and those on tho top are to be laid level and form a moderately fair uniform coping not less than twenty inches in width.

All sharp angular points must be broken off the upper side of the outer stratum of stone, and the interstices between them must be filled with quarry waste, and the whole well pounded and beaten down to a fair surface.

2.—By a covering of pitched stone of an approved class laid at right angles to the face on about twelve inches in depth of quarry waste or gravel. The pitched stone to be in regular courses varying from *four to eight* inches in thickness, and from a depth of twenty two inches at the bottom part to a depth of sixteen inches at the top water line, laid throughout in course sand or fine gravel, and have the joints in the respective ranges properly broken over and with each other.

The whole of the stones to be well rammed and beaten down to a fair uniform surface. To support the toe part of the pitched stone, an oblique or wedge-shaped timber is to be scribed and fastened with bolts one inch diameter let six inches or more into the rock, and where the bottom is clay or other material of that kind the first tier of stones are to be let in their full depth and laid so as to form the toe support.

3.—A wall may be built of a like class of work as that previously described for places where the rock is not more than *seven* feet below the water line.

Contractors are requested to submit a price for each of these three different kinds of protection for the banks, subject to the distinct understanding that they provide, at their own cost, all the necessary materials, and that the work to be done may consist of all *three* kinds, or it may be of *two* of them, or wholly of *one* kind without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

To carry off the surface water that may collect in the ditch at the rear of the towing path and berme bank, drains 12 inches square are to built of rubble masonry covered with flat-bedded stones, the top of which are to be from one to three feet below the surface of the bank.

BACK DITCHES,—to carry off the surface water and such other natural drainage on the south side of the canal as it may be necessary to provide for, are to be formed at the places and of the dimensions required, care being taken that the old ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available.

For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

To form an outlet from the ditches, wells are to be sunk in connection with them, from which off-take drains or culverts are to be made with such inclinations as will discharge the water freely into the canal one foot or more below the surface level of the reach.

These wells will be from two to three feet square, and the culverts from them are to be from fifteen to twenty four inches square. They are to be built of rubble masonry laid in cement mortar, but the bottoms of both wells and culverts are to be of flat stones of a size to reach across the respective openings and pass at least 6 inches under the walls on both sides; the covering of the culverts must also be of flat stones of a length which will bear at least six inches on the side walls. All the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

For the purpose of enabling the deepening of the channel and the widening of it below the water line to be urged forward, the new culvert to be built and the old one removed, the bridge piers and abutments to be built and the present ones removed, the upper part of the present lock to be taken down and rebuilt, the retaining wall below it to be constructed, the foundation of north wall of lock to be secured and wings at the upper end of it to be built, etc., the canal will be emptied as nearly as possible in the early part of December, 1876, and the water allowed to remain out until the latter end of April, 1877.

In December, 1877, the water will again be drawn off and the canal allowed to remain empty until the latter end of April, 1878.

The contractor's arrangements must therefore be such, and his operations be conducted in such a manner that the whole of the works on and connected with this section shall be done between the time of awarding the contract and the 25th day of April, 1878.

In order to effect this object the contractor will be called upon to commence the works immediately after they are awarded, and to proceed with them in such a manner that the widening of the channel way down to ordinary water surface, the formation of the towing paths, etc., shall be completed by the 1st day of October, 1876, and at least one-third of that part of the under water widening through clay, done by the 15th day of November, 1876.

The stone for rebuilding the present lock and constructing the retaining wall below it, must be provided, quarried, prepared and delivered, also cement, sand and other materials delivered by the 1st day of November, 1876, and such derricks and equipments provided and arrangements made as will fully satisfy the Department of Public Works

and its engineers that the rebuilding of the walls of the old lock, the construction of the retaining wall at the lower end of it, and the works connected with securing the foundation of the north wall can all be completed by the latter end of April, 1877.

Contractors should bear in mind when "tendering" that a dam must be made at each end of the section; one at the upper end to prevent water passing on to or coming from Section No. 8, and one at the lower end to guard against water passing on to or coming from Section No. 5. A dam must also be built across the entrance to the raceway leading to the mills at Côte St. Paul.

It should also be borne in mind that all water that may accumulate between the dam at the lower end of the section and the lock must be pumped back into the reach above the lock, and be again lifted before the works can be laid dry.

For the purpose of removing surface water, springs, leakage, snow, ice and any other water that may accumulate on the section, the contractor must therefore provide *three* steam engines and pumps—one to remove the water from the lower reach, and the other two to be placed in the most advantageous positions to lift the water and discharge it into the River St. Pierre, or of disposing of it in some other way, without allowing it to pass on to the adjoining sections.

Contractors should also keep in view the fact that the respective bulk sums for unwatering the different parts of the works must embrace the construction of all dams, the providing and fitting up all pumps and machinery that may be required for that purpose, also their full maintenance and removal when directed, as well as the replacing of them as often as it may be found necessary to fully carry out and complete all the work herein described, or connected with the enlargement of the canal, as contemplated in this specification. It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering all the different parts of the work, and the foundations of all structures on the section must be embraced in the respective bulk sums stated in the tender.

When conducting the works connected with the enlargement and deepening of the channel, as well as placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge. He must also take great care not to cut into the inside slopes, nor do anything at all likely to have a tendency to impair the stability of the banks.

Contractors should bear in mind, when tendering, that black limestone, such as used for ordinary building purposes in Montreal, will not be allowed in any part of the work connected with the section.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of 1½ inches, thoroughly mixed with fresh hydraulic cement, and clean, sharp sand in such proportions as may be required.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be partly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

PUDDLE BED—in rear of the lock walls to be 3 feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

RUBBLE WALLS,—forming the extension of the wings at the head and foot of the lock, must be formed of a large class of sound, well-shaped, durable stones, properly bonded over and with each other, and laid in cement mortar for such a distance below the lock as may be directed.

The walls are to be built to such lines as will form a suitable connection between the lock, the slope walls and inner face of the banks, or retaining walls, as the case may be; and the faces of the stones are to be hammered or scabbled to such batters or lines as may be required to adapt them to the positions they are to occupy in the work.

The different works here in described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan comtemplated in this specification and the direction of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality, and for all such parts of the structures as may be required, will be furnished as the works proceed.

The removal of the present piers and abutments of Côte St. Paul Bridge to be tendered for by the cubic yard, this rate to include the removal of all mason work, crib work, or whatever may be necessary to clear out the channel to the required capacity; the work to be done at the time and in the manner directed by an officer entrusted with that duty by the Department of Public Works.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated or dredged material, or in proceeding with any part of the operations connected with the work, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding, or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The contractor must provide, at his own cost and expense, all the service ground that maybe required for the purpose of placing and preparing materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipments, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works as herein described, and the instructions that may from time to time be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty fifth day of April, 1878.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 23rd February, 1876.

APPENDIX No. 42.

LACHINE CANAL OFFICE,

MONTREAL, 4th December, 1879.

JOHN PAGE, Esq.,

Chief Engineer Public Works,

Ottawa.

SIR:

In compliance with your instructions by telegram of the 8th, directing me to set about preparing a general report on the works under my charge, giving such information and details, etc., as may be useful for future reference, I beg respectfully to submit the following:—

GENERAL REPORT *on Sections numbered 1, 2, 3, 4, 5, 6 and 7 of the Lachine Canal Enlargement, from the commencement of the work to the 1st day of December, 1879.*

SECTION No. 1—includes the construction of two locks and an intervening basin, with a regulating weir and raceway, and bridge abutments, etc., the whole forming a new entrance from the River St. Lawrence to Basin No. 2 of the old canal.

The locks are 270 feet in length between gate quoins, 45 feet in width at bottom and have a depth of 18 feet water on the mitre sills. The basin is 540 feet in length and 240 in width at the east end and 280 at the west end, and has a water depth of 19 feet. It is surrounded by a heavy dock wall of ashlar masonry. The lower entrance to the lower lock is 272 feet in length, and is 100 feet in width at its junction with the harbor and 80 feet at the foot of the lock.

The work, after being advertised, was awarded to A. P. Macdonald & Co., and the contract signed in September, 1873.

SECTION No. 2—embraces the enlargement and deepening of Basin No. 2 and the construction of Wellington Basin, both having a depth of 19 feet. The latter is 1,250 feet in length by 225 feet in breadth, and is also surrounded by a dock wall of ashlar masonry.

The enlargement of Basin No. 2 is made by the removal of a point of land at its upper end. This section was awarded to Lemay & Bowie, and the contract signed early in October, 1873.

In March, 1875, the original contracts for the two sections were cancelled, and the work relet at the same rates to James Worthington & Co.

Lock No. 1.

The excavation of the pit for Lock No. 1 was commenced in September, 1873, but was suspended in December in consequence of the usual winter rise of the River St. Lawrence, until the 17th July, 1874.

The work was then resumed and continued until the 12th of December, when it was again suspended for the same reason. Early in the summer, quarries were opened at Terrebonne, and the contractors commenced preparing stone for the masonry.

During the season of 1874 the whole of Section No. 1 from the head of Lock No. 2 to the foot of Lock No. 1 was drained through the pit of Lock No. 1 to a pump situated at the foot of the lock, and the large quantity of water there collected materially hindered the progress of the excavation. Two fifteen-horse-power engines, working a 15-inch centrifugal pump, were employed during the season to unwater the works. This pump was removed in December and replaced in the spring of 1875 by one 10 inches in diameter, which was driven with greater speed. A small engine and pump were also placed in Basin No. 1 to unwater that work, but the water from Lock No. 2 was still drained through Basin No. 1 to the pump situated at the lower end of Lock No. 1. The water during the season of 1875 was under better control than in 1874, but the quantity coming from Lock No. 2 was a great hindrance to the work.

During the summer of 1874 the pit was excavated to within about 11 feet of foundation level, and in 1875 to within 3 feet of the same level. Further excavation was prevented by water in the pit, the pump not having been placed sufficiently low to favor its further removal.

After the usual season of high water during the winter, a heavier engine and larger pump were put in position and the works unwatered. Excavation was again commenced on the 7th July, 1876, and continued during the balance of the season.

At the upper end of the pit the bottom was very soft, so that it was necessary to drive sheet piles along the edge of the pit to prevent the sides from running in. Piles 8 inches in thickness were also driven along the face line of the lock walls, and the bottom excavated from 9 to 12 inches below the foundation timbers and filled with concrete, to support the masonry and prevent it from settling into the soft material and forcing it towards the centre of the lock.

At the close of the season the excavation was completed, except about 1,000 yards at the lower end, and the foundation formed of concrete, timber and plank laid for a distance of 170 feet from the upper end.

The masonry, which was commenced on the 30th of October, 1876, at the breast wall, was continued downwards on both sides for a distance of 130 feet and to a height of 5 feet.

A large quantity of stone was also placed on the timber foundation to prevent it from rising during high water.

Considerable difficulty was experienced in excavating trenches for the sheet piles and anchor timbers at the upper and lower sides of the upper mitre sill platform, owing to a large amount of water coming into the trenches through a stratum of gravel.

A slide from the side of the excavation at the upper end of the pit on the south side also occurred.

During the winter and spring the work was flooded by high water from the river and again unwatered on the 16th of May, 1877, and the work resumed.

During the balance of the season the foundation was completed and the masonry at the upper end built up to the height of 29 feet and at the lower end to the height of 25 feet. The wing walls at the upper end of the lock were also built up to the same height as the lock walls, and connected with the walls of Basin No. 1. The placing of the lower mitre sill platform and the foundation above and below the same was very much obstructed by water and sand running into the pit.

On the 2nd of August a heavy leak came in, apparently from the old canal, which was stopped by loading a large amount of stone on the slope to consolidate the bank and close the water-course through the same.

On the 15th September the water broke in again and was stopped in the same manner. Another small flow of water came from under the concrete foundation for the lower mitre sill platform after the upper and lower timbers of the same and the sheet piles and anchor timbers had been put in, causing one end of the sheet pile timbers and sheet piles and a portion of the concrete to settle from one to seven inches. To secure the work, a row of piles 10 inches square and 15 feet long were driven 5 feet below the mitre sill platform, and another row of the same size from 16 to 20 feet in length were driven at the foot of the lock; a course of sheet piles 4 inches thick and 8 feet in length were also driven 3 feet above the last. Concrete from 2 to 2½ feet deep was put under the foundation from the mitre sill platform to the foot of the lock.

The laying of masonry was discontinued on the 1st of November and resumed on the 25th of May, 1878, and completed in October. The unwatering of the work was discontinued in the fall of 1877, and no further pumping has since been required.

During the autumn of 1878, the lower entrance to the lock was dredged out and a timber docking with plank covering formed at the side. This docking connects on each side at the lower end of the entrance with the harbor works.

In the month of April last, the water in the river rose over the walls of the lock, and when it subsided it was discovered that the greater part of the coping of the lock walls had been displaced. On the 26th May, the contractors set a gang of masons and laborers to reset the same. The progress of the work was very much delayed during the summer, but was finally completed in September, and the coping further secured by 1½ inch round bolts set 4 feet into the masonry and well leaded in.

Mooring hooks were also secured to the wall by anchor bolts, and mooring posts are ready to be placed in the wharf on each side of entrance below the lock.

Basin No. 1.

The excavation for this basin was commenced in September, 1873, but was discontinued during the season of high water.

It was resumed on the 17th July, 1874, and carried on until the 12th December, when work was again suspended by high water in the river, but during the time a large quantity of stone was prepared at Terrebonne quarries for the work.

On the 14th June, 1875, the basin was again unwatered and the work of excavation again resumed. The foundation of timber and plank for the dock wall was commenced on the 24th June, and on the 30th the masonry was also commenced, and was built up during the summer on the east side and on the north and south ends to an average height of 18 feet. The work was discontinued on the 1st November, and resumed on the 5th June.

During the summer of 1876 the dock walls at both ends and on the south side were completed, except the coping and as much as was necessary to connect them at the lower end with Lock No. 1, and at the upper end with Lock No. 2. The wall on the north side was finished at the same time, except the portion necessary to connect with Lock No. 1. Excavation was also completed, except a small portion in the centre, which was reserved for filling behind the masonry.

Included in the excavation was considerable old crib work which had to be removed to make room for the north wall of the basin.

During the winter and spring the basin was again flooded by the river. It was unwatered on the 16th May, 1877, and the work resumed.

During the summer of 1877, the wall at the south end of the basin was connected with Lock No. 2, and the excavation completed.

During the summer of 1878 the work, including the south dock walls, the wharf on the south side and at the ends, the macadam road in rear of the same and also between the old and new basins, the pitched stone facing to banks on the south side and at the foot of the basin, the water-table between the basin and between the old and new locks were all completed and the mooring hooks anchored to the walls.

In 1879 the coping was bolted down with $1\frac{1}{8}$ inch round bolts about 4 feet long, reaching down into the heavy course of masonry and well leaded in.

Lock No. 2.

This lock and its upper entrance occupy the sites of the three combined locks built in 1822 and extends about 60 feet below the lowest lock, the foundation of which is at the same level as the new lock. At the upper end of the new lock for a distance of about 50 feet, the foundation is nearly 8 feet lower than that of the old centre lock.

The excavation of the pit for the new lock was commenced in October, 1873, was discontinued during the winter months and resumed in March.

During the summer of 1874 the greater part of the south wall of the old lock and foundation up to the head of the new lock were removed.

A temporary bridge near the head of the lock was completed in July and was in use until a new bridge was completed last spring.

A cast iron pipe 18 inches in diameter was also laid to drain the water from the turbine wheel which was used for turning the swing bridge at the head of old Lock No. 2. It runs by the south side of the old lock and discharges into the basin at its foot.

The work at the new lock was discontinued during the winter and resumed on the 9th June, 1875. The foundation was commenced at the head of the lock on 27th June and masonry on the 27th October.

The walls on both sides of the chamber of the lock were built up to an average height of three feet and at the upper recess and breast wall to the height of 5 feet. The foundation was put in from the head of the lock to the lower end of the mitre sill platform, and the work closed for the season on the 15th November.

The material in the bottom of the pit except at the upper end was fine sand. It was excavated to a depth of from 6 to 21 inches lower than the timber foundation, and concrete put in its place as well as between the timbers. The line of the lock was located parallel to the line of the old locks and so that the face of the north wall is 10 feet in front of the face of the north wall of those locks. At the upper end the foundation is nearly 8 feet lower than the foundation of the old work, and as the excavation progressed stout vertical timbers, resting on broad, thick plank were driven under the face of the old masonry with great care so as to give a substantial support to the old work, and 3-inch plank put in behind to keep the earth in place. As the new wall was built up concrete and masonry were also built under the face of the old wall. While the foundation was being put down at this place the water at the wheel used for turning the bridge formed a course through, behind and under the old wall, and considerable water and earth ran into the lock pit, which had to be removed. The water to the wheel was soon shut off and the bridge was afterwards worked with a horse. Below the point above referred to a portion of the invert of the old lock was left in place and about 8 feet in width of the new wall built thereon, and 2 feet in width built on the new foundation.

The whole work was suspended during the winter and again unwatered and the work resumed on the 7th July, 1876. The concrete and timber foundation below the lower mitre sill was completed early in the summer and the lock wing walls connected with the dock walls of Basin No. 1. At the close of the season the side and wing walls were built up to an average height of 21 feet and the breast wall completed.

The work was again discontinued during the winter.

It was resumed early in 1877 and the bridge abutment and new portion of wall above the old lock were nearly completed in the spring previous to the opening of navigation. The masonry forming the recess at the head of the lock for a submerged gate and the bridge abutment on the south side were well advanced in the early part of the summer. During the latter part of the season the masonry of the lock was completed, the bridge abutments and bridge over the tail race at Mill Street were constructed and a large portion of the excavaion for the upper entrance and raceway was removed. During the winter and spring the balance of the excavation was removed. The foundation for the retaining wall and weir above the lock was commenced on the 4th April, 1878. And previous to the opening of navigation the masonry of the weir and retaining wall was completed and a stop gate built in the recess prepared for it at the head of the lock.

The sluices through the weir were also closed by temporary gates to exclude the canal water from the raceway and give the contractors an opportunity to finish the same during the summer. The stop gate and temporary gates for the weir not being included in the contract, were built by day's labour under the supervision of the Canal Superintendent.

Before the season closed, the timber and plank flooring of the raceways had been completed and the side walls finished.

The work was suspended during the winter and again resumed on the 28th March last. Previous to the opening of navigation on the 4th May, the pivot pier for the Mill

Street Bridge was built and the abutments finished. The old bridge was removed by the Superintendent and a new bridge built by Mr. Bartley, the contractor for the same.

The parapet piers on each side of the roadway, at the abutments, have since been built, the roads graded and the balance of the work completed.

Basin No. 2.

The enlargement of this basin was commenced on the 28th November, 1874, by excavating in the point of land at its upper end. Operations were continued during the winter, and suspended for a short time on the 13th of March. During the summer and fall of 1875 the excavation for the enlargement of the basin at its upper end was continued, partly by men and horses, and partly by the steam excavator which had been working in Wellington Basin. A steam dredge was also employed deepening the bottom of the basin. Work was suspended during the winter and resumed early in the spring of 1876; it was continued with two steam dredges and an excavator until the 30th September, when the water broke into Wellington Basin and also flooded the portion of Basin No. 2, when the enlargement was being made, and stopped further operations with the excavator.

Operations were resumed in the following winter with men and horses, and considerable excavation was taken out.

After the opening of navigation the dredges were again put to work in the basin, one working in 13 feet of water and the other in the 19-foot channel. At the end of the season the greater part of the material, down to the level of 13 feet below surface water, and about 25 per cent. of the 19-foot channel was taken out.

The work was suspended during the following winter, but early in the spring of 1878, before the opening of navigation, a large amount of excavation was taken out with horses and carts, along the south side of the basin and in the deep channel, which was extended to connect with the head of Lock No. 2. One side of this channel or entrance is close to the south wall of the basin, where it connects with the new retaining wall above the lock and the foundation of the basin wall was only 10 feet below surface water. To keep this wall in place the earth under its face was removed in sections, and vertical posts, resting upon broad and thick plank, were immediately forced under with great lifting power; masonry was then built underneath, projecting some two feet beyond the face of the old wall.

After the opening of navigation, dredging was again resumed and continued until fall, when operations were again suspended during the winter.

Early in the spring of 1879, before the opening of navigation, the contractors put men at work into the bottom to level off the portion which had been excavated by the dredges, to the level of thirteen feet below surface water, and left in a rough state by said dredges. Some excavation was also done in the south-west corner of the basin.

Soon after the opening of navigation the dredging was again resumed, and was continued until the 8th November, when the work was discontinued.

Wellington Basin.

Excavation for Wellington Basin was commenced in October, 1879, by Lemay & Bowie, the original contractors, and continued at intervals during the winter. A large amount of stone for dock walls, with timber and plank for the foundation of the same, were also delivered during the winter.

On the 16th July, 1874, the excavation at the west end of the basin having been taken out to the required level, and a portion of the foundation put down, the dock wall masonry was commenced at the north-west corner of the basin. Good progress was made on the work during the remainder of the season, which closed on the 21st October.

The excavation at the early stage of the work was carried on by men and horses, and the largest portion of the material so removed was deposited on embankment around the basin. About 1,200 cubic yards were deposited on private property in the vicinity. On the 15th August the contractors procured a large steam excavator, which they worked in connection with cars and engines on a railway track. This track was connected with the Grand Trunk Railway at the Point St. Charles Station, and two trains were used to remove the material excavated, which was placed on the railway grounds, in the vicinity of the Victoria Bridge, to raise the tracks.

Operations with the excavator were discontinued on the 16th December, owing to heavy snow storms, but men and horses were employed until the 26th, when the work was again suspended.

Excavation was resumed on the 26th April, 1875, and masonry on the 1st May; good progress was made during the season on the whole work.

Stones for the dock walls were procured at a quarry near Terrebonne, where the contractors kept a large force of men employed at quarrying and dressing them. They were hauled to the river at Terrebonne, and steam tugs and barges were used to deliver them on the work.

From the commencement of the work to the 17th August, 1874, a small portable engine was used for unwatering the basin, but as it would not fully answer the purpose during the heavy falls of rain, it was removed, and an engine of 20 horse power, with a large pump, was substituted.

The work was again resumed in the spring of 1876, and good progress was made on the whole until the 30th September, when the water from the canal broke into excavation, causing a suspension of the work for the balance of the season. The break was caused by the imprudence of the contractors in excavating too near the canal after being cautioned and directed not to do so.

The excavation and masonry were at this time nearly completed, and the brick sewer connected with the work, which was commenced in the spring, was nearly finished.

The water being out of the canal, work on the dock walls was again resumed on the 16th March, 1877, and previous to the opening of navigation the unfinished portion was built up to above water surface. At the close of the season the sewer was finished, and the masonry and wharf around the basin were nearly completed.

In 1878 the mooring heads were let into the coping and secured with anchor bolts, and the bank in rear of the wharves graded. The work is now completed in a satisfactory manner.

Section No. 3.

The work on this section was awarded to Messrs. McNamee, Gaherty & Fréchette, who signed the contract on the 20th November, 1875.

The section extends from Station 8, at the upper end of Basin No. 2, to Station 50, about 700 feet above the St. Gabriel Lock, and is a little more than three-fourths of a mile in length. The work consisted chiefly in the enlargement of the channel to a mean width of 200 feet, and to a depth of 13 feet below the assumed water line; building piers and abutments for the Wellington Street and Grand Trunk Railway bridges; the construction of a lift lock, regulating weir, raceway and bridge abutments; taking down the upper part of the old Lock No. 3 and rebuilding it with new face stone; extending the north wall from the lower end to connect with the new lock; forming a temporary regulating weir and raceway on the south side of the old lock, and building a dock wall on the south side and on the lower portion of the north side of the canal.

Excavation was commenced on this section, on the north side of the canal above the St. Gabriel Basins, on the 3rd January, 1876, and was carried on until the 1st April, when the work was discontinned on account of the spring freshets.

It was resumed again in May, and embankments were made to enlarge the canal outside the old banks, on the north side from St. Gabriel Basins, to the tail race below St. Gabriel Lock and on the south side from Wellington Bridge upwards for about 800 feet. The north bank was completed and the water let into the cut on that side on the 28th July.

Two powerful dredges with a steam derrick for unloading the excavated material commenced work on the 7th July in the prism of the canal between Wellington Bridge and St. Gabriel Lock. About three-fourths of the excavation on that portion of the enlargement was done at the close of navigation.

The dock wall on the south side above Wellington Bridge was commenced on the 7th August and at the close of the season 760 lineal feet of it had been completed, with the exception of the coping.

A large quantity of stone, timber and plank was also delivered, and steam derricks and travellers provided for carrying on the work to the greatest advantage.

As soon as the canal was unwatered, excavation was commenced in rear of the old lock, and the walls of the upper recess and chambers were taken down to the depth of 13 feet, and at lower recess and wings they were entirely removed.

On the 5th February, 1877, the contractors commenced the removal of snow and ice at the foot of the lock, to make room for a coffer dam, and to excavate the earth for the foundation of the retaining wall, to connect the lower north wing of the old lock with the south wing of the new one. On the 16th of the same month, work was begun on the concrete wall, in rear of the north wall of the old lock. Its foundation was carried down to the full depth of the foundation of the new lock, which is 5 feet lower than that of the old one. On the 5th March, the foundation of timber, plank and concrete for the retaining wall above mentioned was prepared, and the masonry commenced.

The lock wall was commenced on the 14th March and the whole completed and ready for the opening of navigation on the 5th May. Previous to this time, a temporary weir and raceway were also constructed on the south side of the present lock, it was built of timber, plank, etc., and the work done by the day, under the direction of the Superintendent, Mr. Conway. Two abutments and a centre pier were erected for a fixed bridge over the upper entrance to the new weir, which is also a head race for manufacturing purposes; the site of the new lock and weir pits were enclosed by coffer dams and the excavation commenced.

When the water was let into the canal in May, a bad leak was found to be running under the foundation of the old lock into the pit of the new one. This was staunched by driving piles in rear of the lock walls and filling with concrete between the piles and the wall.

During the summer and fall of 1877, the excavation of the pit for the new lock was completed, the foundation put in and the masonry from the lower end to the upper hollow quoins built to a height of 16 feet, and during the following winter and spring, previous to the opening of navigation, the pitched stone facing to banks above the lock, on the south side of the canal, was built, and the remainder of the docking wall, about 2,500 feet in length, was constructed to surface water. The pit for the weir was also excavated, the foundation laid and the masonry built, the south wall of which was connected with the bridge over the raceway above the weir, and the north wall with the masonry of the head race leading to the mills below Seigneurs Street. About 250 feet of the foundation of the new raceway was also put down, and the masonry built up to the height of surface water. The retaining wall below the lock to connect with the tail race from the weir was extended to nearly the length required; the side walls at the upper recess of the lock and the breast wall built, the wall above on the south side extended 82 feet, and considerable excavation done at the upper end of the section.

After the opening of navigation in 1878, and during the following season, the side walls of the new lock were raised to their full height, and the wall above on the north side extended 104 feet, to form an abutment for a new bridge. A retaining wall, 115 feet in length above the last, nearly completed, and the greater part of the dock wall on the south side of the canal finished to its full height. The segment plates and second course of plank were put into the new lock and the gates and machinery for the new weir put into place. A pavement, 2 feet in depth and 30 feet in length, was put in at the foot of the new lock and grouted. Concrete was put in at the upper side of the breast wall of the lock and at the toe of the walls above the same, and a pitched wall extended on the north side, nearly to the upper end of the section, the old bank being left in to prevent the water breaking through into the work.

During the following winter and previous to the time of again letting the water into the canal, on the 4th May, 1879, the greater part of the material for the Wellington Bridge was procured, the excavation taken out, the masonry in piers and abutments and the crib work in connection with the same constructed to the height of 2 feet over water surface and filled with stone, and the bridges constructed on the works, ready for use. A temporary bridge for the railway track and one for the Wellington Street traffic were also constructed, and the old bridge and its abutments and piers removed while the work was in progress. The head race north of the McGauvran Island, leading into the weir, was enlarged and deepened, and a pitched stone wall on a slope of $\frac{1}{2}$ to 1, $2\frac{1}{2}$ feet thick at top and 3 feet at bottom, with 1 foot of quarry waste in rear, has been built on both sides. It is from 70 to 95 feet in width and 13 in depth below water surface, and is connected with the main canal by a new cut around the west end of the island, which is also protected by a wall, the same as above described.

A new wall laid in cement was also built on the west side of the head race, leading to the mills below Seigneurs Street, and the bridge over the same thoroughly repaired.

The raceway below the new weir was completed, the breast wall below the same put in and the south wing connected with the retaining wall below the new lock. A temporary bridge was constructed to divert the traffic at St. Gabriel, the wall at the head of the new lock on the south side was extended and connected with the masonry at the head of the old lock and a pivot pier for the new bridge was built. Protection cribs were also constructed and filled with stone, above the masonry at the head of the old lock,

one on the north and one on the south side; the cribs were further protected by clusters of piles set above them, which were bolted and bound together.

Since the canal was filled last spring, cluster of piles have been driven for the protection of the wing walls at the lower end of the raceway above described. On the south side of the canal above Wellington Bridge a piece of road has been graded and macadamized in place of the road destroyed by the enlargement, and the road above the same, which was seriously injured, has been thoroughly repaired. A new road has also been graded and macadamized at both ends of the Wellington Bridge, the crib work of the bridge has been finished and stone has been delivered and is being prepared for finishing the masonry connected with the new bridge abutments, etc., at the St. Gabriel Locks. The last work mentioned cannot be finished until the close of navigation, when the travel can be diverted to the temporary bridge constructed last winter. The whole work under the contract is now completed with the exception of the finishing of the bridge abutment, wing walls, etc., above referred to.

SECTION No. 4.

This section extends from Station No. 50, about 660 feet above the head of the St. Gabriel Lock to Station No. 88, a very short distance above the Grand Trunk Railway bridge, a distance of 3,800 feet. The work consisted in widening and deepening the prism of the canal, the construction of piers and abutments for the Brewster and Grand Trunk Railway bridges and alterations to the Montreal Water Works culvert for passing the pipes under the canal.

The water-way of the canal has been enlarged to a mean width of 200 feet and to a depth of 4 feet below the top of the lower mitre sill of the old lock at Cote St. Paul.

The contract for the execution of the work was signed by the contractors, Messrs. Whitney & Doty, on the 6th of April, 1876, and the work was commenced on the 8th of the following month.

The enlargement at the upper end of the section was mostly on the south side of the canal and a new cut was made outside of the old towing path. A new bank was formed outside of the cut, a trench excavated for the foundation of the pitched stone facing to banks, and the walls from Brewster's Bridge to the Grand Trunk Railway well started before the cold weather came on. A large amount of dredging was also done during the same time along the north side of the canal, stone and timber furnished and prepared for the masonry and cribs at Brewster's Bridge.

While the excavation for the foundation of the wall on the south side of the canal was in progress, a deep muck and peat bed was opened which extended under the old bank, the drainage from which caused the old bank to settle. To secure this bank it was loaded with loose stone on the outside and the top, and inner side of the bank raised with earth taken by dredging from the bottom of the canal and taken to the bank on scows.

To secure a good foundation for the wall at this place, after the water was taken out of the canal, deep excavations were made in the muck and peat and the same filled with stone. This work was done in short lengths, to keep the bank from sliding in as the work progressed. An extra quantity of water came into these excavations while the work was being done.

Previous to the opening of navigation, in the spring of 1877, the south bank of the canal, which separated it from the new cut above mentioned, was removed, the wall on the north side for the same distance well started, a temporary bridge was built on wooden

bents and the piers and abutments, as well as the crib work for Brewster's bridge, constructed.

A swing bridge, 120 feet long, and two fixed bridges, each 38 feet long, were also built in place of the old one, on the piers and abutments above mentioned. The material of the old bridge was used as far as practicable in the construction of the new ones, and the work done under the direction of the superintendent, Mr. Conway.

On the 28th March, in consequence of heavy rains at that time, the water from section 5 broke through the dam at the upper end of this section and flooded the whole work. The contractors immediately set their pumps running to their full capacity, and as soon as possible repaired the dam, but it was several days before they were able to resume work.

During the summer of 1877 the contractors finished the work at Brewster's Bridge, dredged the lower portion of the section, delivered stone for the balance of the side walls, and prepared stone for the piers and abutments of the railway bridge. They also excavated through the island at the lower end of the section and built as much of the wall as the space would allow, while the water was in the canal.

During the winter and spring following, the excavation was completed, the remainder of the side walls on both sides of the canal finished, and the abutments and piers for the railway bridge constructed.

The whole work was completed in the spring of 1878 and the final estimate forwarded to the Chief Engineer on the 20th May, 1879.

SECTION No. 5.

This section extends from Station No. 88, above the Grand Trunk Railway bridge, to Station No. 130, opposite the lower factories at Côte St. Paul, a distance of 4,200 feet.

The work consisted in widening and deepening the prism of the old canal, the construction of side walls and an inverted syphon culvert to carry the waters of the River St. Pierre under the canal.

The contract for the execution of the work was signed by the contractor, Mr. Alphonse Charlebois, on the 6th April, 1876, and work commenced on the 13th June, on the north side of the canal, at the upper end of the section.

The canal has been enlarged to a mean width of 200 feet and sunk to depth of 4 feet below the level of the top of the lower mitre sill of the old lock at Côte St. Paul.

The enlargement on this section is mostly on the north side of the canal, but at the lower end there is quite a breadth on the south side. During the summer and fall of 1876, nearly all of the excavation that could be taken out without endangering the banks of the old canal was removed and a new bank formed.

Near the upper end of the section there was a large deposit of muck and marl on a bed of soft clay, along the north side of the canal; to secure a proper seat for the bank and foundation of the side walls, this deposit had to be removed to a depth of from 3 to 4 feet below canal bottom, and a foundation of selected material put in and the bank formed.

Owing to the soft and slippery nature of the bank outside the cutting, it was necessary to take it out and fill in again in short stretches.

The side wall at the upper end of the section was built for a length of 550 feet to an average height of 8½ feet. The pit at the north end of the culvert was excavated and the timber foundation laid.

A large amount of excavation was also done on the south side of the old canal at the lower end of the section and a new bank formed. A steam dredge was employed on the inside slopes and bottom of the canal from the 15th August to the close of the season.

During the winter, excavation was carried on in the bottom of the canal, a portion of the old bank on the north side removed and the side walls built. On the 28th March the works were inundated by water flowing over the dam at the upper end of the section, from Section No. 6. After 11 days it was again unwatered and the work continued.

Dredging was resumed in the spring of 1877, and continued throughout the summer and autumn of 1877, and the ends of the River St. Pierre culvert and the side walls on the new embankment outside of the old canal were built. The remainder of the side walls were nearly finished during the following winter, and in the spring the arches of the St. Pierre culvert were constructed. The ends were completed in August, and the dredging was finished on the 11th November, 1878. During the following winter and spring the bottom was levelled off, the earth and rock taken out. The entire section was completed in May last, and the final estimate was forwarded to the Chief Engineer on the 24th November, 1879.

Sections Nos. 6 & 7.

These two sections were let in one contract to Messrs. Davis & Sons, and the contract was signed on the 26th April, 1876. The total length of the work is 10,000 feet and extends from Station No. 130, about 700 feet below Côte St. Paul Lock to Station No. 230.

The work consisted chiefly in the enlargement of the channel above Station No. 146, to a mean width of 150 feet and to a depth of four and ½ feet below the mitre sill of the old guard lock at Lachine; forming an inverted syphon culvert under the canal; building a by-wash, piers and abutments for a swing bridge at Côte St. Paul; constructing a new lift lock at the latter place, taking down the upper 13 feet or more of the old lock and rebuilding it with new face stone; protecting the north wall and foundation with concrete and extending it to connect with the lower end of the new lock; enlarging the channel below the lock to 200 feet mean width, and facing the inside slopes with pitched stone, etc., etc.

The excavation of the prism of canal and lock pit outside of the old north bank was commenced on the 13th June 1876, and before the close of the season the new bank formed from the lower end of Section No. 6 to the Côte St. Paul Road, a distance of 1,400 feet, and all of the excavation that could be removed with safety on this portion was taken out. Part of this work was attended with great difficulty, as muck and marl above the lock, under the rear of the old bank, extending to a depth of 10 to 12 feet below canal bottom, had to be removed and the space refilled with selected material, to form a suitable foundation for the new bank.

Two steam dredges with a steam derrick for discharging the material over the bank commenced operations at the upper end of Section No. 7 on the 1st September, and worked until the middle of November.

As soon as navigation closed, the contractors began to excavate in rear of the walls of the old lock and to take them down; this work was continued until the walls on both

sides above the lower recess were taken down to the depth of 14 feet, and along the recess and to the foot of the lock, to the foundation.

In February, the concrete wall was formed in a trench in rear of the old lock and the foundation of the retaining wall at the foot of the lock prepared, both of which are 5 feet below the foundation of the old lock.

On the 28th February, the masonry was commenced and building was carried on steadily, until the retaining wall was raised above the level of the water in the lower reach, the lock walls rebuilt and navigation resumed. During the latter part of the winter, that portion of Section No. 6 below the lock and between the old banks was excavated to the grade of the new canal bottom.

The foundation of the new lock at Côte St. Paul, including the mitre sill platforms and mitre sills, were laid during the summer of 1877, and the walls were built to a height of 9 feet.

The by-wash and north abutment for the Côte St. Paul bridge and both ends of the culvert on section 7 were also built, the Cote St. Paul Road at the north end of the bridge was graded and macadamized, and a large amount of excavation done by dredges during the same summer.

The foundation of the new lock was put in close alongside and 5 feet below the foundation of the old lock, and considerable difficulty was experienced in doing the work. The water came in from the old lock and endangered its foundations above the breast wall. To support the bank and make the work secure, it was temporarily braced with timber, and a heavy rubble wall of masonry put in between the locks, before the foundation of the new lock could be put in.

During the winter and spring of 1878, excavations were made for the piers and south abutment for the Côte St. Paul Bridge, and for the culvert on Section 7, as well as for the slope wall on the north side of both sections, and a large amount of side walls built. A temporary bridge for the Côte St. Paul Road was also constructed, and before the opening of navigation, the masonry in the bridge pier and abutments was nearly completed; the arch of the culvert constructed and connected with masonry at the ends previously built, and more side walls of different kinds put in.

At the Côte St. Paul Road, a swing bridge. 120 feet long and 12 feet wide and two fixed bridges, each 38 feet long and 16 feet wide, which had been prepared during the winter, were placed in position as soon as the masonry was ready for them. The material of the old bridge, as far as suitable for the purpose, was used in the new work. This swing bridge, which works on a centre pivot and covers two spans, each 46 feet in width, is very easily worked.

A sluice gate with machinery to work it was also prepared and placed in the new by-wash.

The bridge and gate were built by day labour, under the direction of the Canal Superintendent.

The masonry in the new lock was completed in July, 1878, and in August the random coursed masonry at the two ends, to connect with the slope wall, was also completed.

An underground off-take drain on the south side of the canal, and a paved drain and macadamized road on the north side below the Côte St. Paul Bridge, were completed the same season.

Four dredges were employed during the greater part of the season, and their work was finally closed on the 26th November.

The water was let out of the canal on the 4th December, and soon after the contractors put on a large force to finish the bottom of canal and side walls. A crib filled with stone was constructed at the upper end of the pier above the locks, and a cluster of piles was set above the same, which was bolted and bound with iron. The work was continued during the winter, with a short intermission, and soon after the water was let into the canal. Last spring the banks were finished and the entire work completed in June.

I have the honor to be,

Sir,

Your obedient servant,

H. K. JOSLIN,

Resident Assistant Engineer.

APPENDIX No. 43.

LACHINE CANAL.

SPECIFICATION of the Work to be done on SECTION No. EIGHT of the Enlargement.

This section is 7,500 feet in length, and is bounded by Stations Nos. 305 and 230, as represented on the plan exhibited.

The work upon it consists in widening and deepening the prism of the present canal, and depositing the material excavated chiefly on the north side of the line, at such places on and opposite the lower two-thirds of the section, or between Stations Nos. 230 and 280, as may be directed.

The channel is to be enlarged to a mean width of one hundred and fifty feet, and sunk to the depth of fully four and one-seventh feet below the top of the mitre sills of the present guard lock at Lachine.

At the upper end of the section the cutting, for about 2½ feet over the water line, will be in rock, the surface of which, for a distance of 500 feet, has a slight declivity towards the east; thence the inclination is such that within the next 500 feet the surface of the rock is nearly the same level as the bottom of the present canal, and continues at that height on other parts of the section, except at places where it underlies a hard class of material consisting of clay, gravel and boulder stones firmly cemented together.

In rock cutting the side slopes are generally to be made one-fourth horizontal to one vertical; and in earth or clay, where the depth below the water line to the rock is less than seven feet, or where vertical walls are to be built, the sides are to be made with as little slope as circumstances will admit.

At other places the side slopes may vary from one-half horizontal to one vertical, or be made to an angle of forty five degrees; otherwise they may be made two horizontal to

one vertical, or of any other inclination intermediate between the least and greatest slopes above mentioned as may be directed.

From the lower end of the section upwards for a distance of about 2,500 feet, the widening will be done chiefly on the south side of the present line; but at Station No. 260, and for such a distance above and below it as required by the curvature, the increased width will be taken off the north side; thence upwards the widening will be done on both sides.

The side lines of the enlargement will generally correspond with those marked in red on the plans exhibited; but the Department of Public Works reserves to itself the right of changing the whole or any part of the line to such an extent as will admit of forming an entire new channel on either side of the present line, or of widening out the existing channel on either one side or the other, or of increasing the width on both sides, as may be subsequently determined.

These changes, it is to be clearly and distinctly understood, may be made either before the operations are commenced or during their progress without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The material excavated for both the widening and deepening on the lower two-thirds of the section can be deposited on the north side of the canal at a distance of one hundred and fifty feet from the centre line, and generally opposite the place where the work is done. But on the lower half of the section sufficient material must be placed on the south side adjoining canal property to form a road-way of such width and height as the officer in charge may consider necessary for the accommodation of public travel.

The material excavated in deepening and widening the upper one-third (2,500 feet) of the Section must be hauled and placed on the north side of the canal to the eastward of Station No. 280, that is to say, the average haul for this stretch of the work will be about one-third of a mile (1,760 feet).

Spoil Banks—to be formed with approved uniform slopes, and must invariably be made of a regular height, and their tops have a declivity outwards from the canal.

All stones found in the excavation that may be considered suitable for building purposes, but not required for work connected with this section, must be hauled and piled by the contractor at such places, between Stations Nos. 280 and 230, as may be directed by the officer in charge.

Towing Paths.—At the places where the work connected with widening the prism is on the north side of the present channel, a towing path of the full width must be continued and formed either as a whole or in part as may be required.

It is to be made 18 feet in width and of a like elevation over the water line as the one now in use; at places where the bank in rear of it is of a greater height, a ditch 2½ feet wide at bottom must be cut at the foot of the slope, towards which the top of the trackway shall have a declivity of one foot transversely. The bottom of the ditch to have such an inclination as will carry the surface water freely to off-take drains formed at such places as circumstances may require.

On the south side of the canal, if directed, a berme bank is to be left or formed and in either case graded at the height of 18 feet over bottom, made 12 feet wide on top, with

a declivity outwards to a catch-water drain cut in the rear of it where necessary, from which suitable cross-drains are to be made as described for the towing path on the north side.

SIDES TO BE TRIMMED.—The prism of the canal, as already stated, is to be excavated to a mean width of 150 feet, *i.e.*, between the bottom and surface water levels. This width is to be maintained in both rock and clay excavation and the slopes made to the respective inclinations above mentioned. It is also to be clearly and distinctly understood that the contractor shall excavate and form to a slope of one-quarter horizontal to one vertical, all other parts of both the north and south sides of the present rock cut within the limits of the section, as well as those at the places where excavation is to be done for the widening of the channel. In every case all angular and projecting points of rock must be broken off, and the side slopes invariably trimmed to fair and uniform lines corresponding to those marked out by the officer in charge.

For the entire length of the section and width of the channel the bottom must be sunk to an uniform depth of four and one-seventh feet below the top of the mitre sills of the present guard lock at Lachine, or to a greater depth if rendered necessary by the thickness of the lower stratum of rock that has to be removed.

In the event of it being considered necessary to cut into the north bank at any place where it passes through or is immediately alongside of low ground, a new bank must be formed or an additional width given to the present one as circumstances may require. In all such cases the space to be occupied by the bank must be cleared of all stumps, roots and logs, and all sods, turf, muck and loose earth must also be removed for such a depth as may be necessary to secure a water-tight connection between the ends and sides of the old and new parts of the banks, as well as between the new banks and seat prepared for them.

To render the banks at such places still more secure, as well as at any other place where the officer in charge may consider necessary, a trench from 4 to 6 feet in width, of such a depth and length as may be directed, is to be excavated at the front line, or in such other position under the towing path as may subsequently be determined, in which a puddle bank or wall is to be carried up to a foot or more over water line.

PUDDLE,—where used, must be made of the best description of material for the purpose that can be obtained at any place on the section, or within half a mile to the north or south of where it is to be used. It is to be laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form puddle walls impervious to water.

It will be observed from the situation of the work that a considerable extent of that part of it through clay cutting can be done by machinery during the summer months, provided proper precautions are adopted to guard against interfering with the navigation.

Contractors will therefore be expected and required to provide the necessary equipment for that purpose, and be prepared to move, haul, transport and elevate the material in such a manner as will enable it to be expeditiously taken to and deposited at the places above mentioned, unless they are able to show to the full satisfaction of the Department of Public Works that they are in a position to execute the work in some other way, in a more advantageous manner, within the time agreed upon for its completion.

Parties tendering are requested to bear in mind that in the disposal of the excavated or dredged material, as well as in all matters connected with the prosecution of the works,

or in making arrangements for that purpose, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel when passing through the canal may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

For the purpose of enabling the deepening of the channel and the widening of it below the water surface to be proceeded with, the canal will be emptied in the early part of December, 1876, and the water be allowed to remain out until the latter end of April, 1877.

In December, 1877, the water will again be drawn off and the canal allowed to remain empty until the latter end of April, 1878.

The contractor's arrangements must, therefore, be such, and his operations be conducted in such a manner that the whole of the works on and connected with this section shall be done between the time of awarding the contract and the 25th day of April, 1878.

In order to effect this object the contractor will be called upon to commence the works immediately after they are awarded, and to proceed with them in such a manner that the widening of the channel-way down to ordinary water surface, the formation of the towing paths, etc., shall be completed by the 1st day of October, 1876, and at least one-third of that part of the under water widening through clay done by the 15th day of November, 1876. During the summer months of the present year all such works are to be proceeded with, such drilling done, and arrangements made as will enable the widening of the rock part of the section to be commenced and vigorously carried on as soon as the season of navigation is closed.

To accomplish this the contractor must provide, within thirty days after having been requested to do so, all necessary derricks, drilling machines, pumps, engines, dredging machines and their equipment, plant, tools, etc., required to urge forward the operations in an energetic manner, to the full satisfaction of the Minister of Public Works and his engineers.

For the purpose of removing surface water, springs, leakage, snow, ice or any other accumulation of water on the section, a steam engine and pumps must be provided, and placed in the most advantageous position to lift the water and discharge it into the River St. Pierre, or of disposing of it in some other way without allowing it to pass on to the adjoining sections.

A dam is to be formed at each end of the section of such a height as will at the upper end prevent water passing on to or coming from Section No. 9, and at the lower end prevent water passing on to or coming from Section No. 7, as well as to direct the water in both cases towards the pump.

Contractors should bear in mind that the items for dams, pumps and machinery for unwatering this section should embrace the cost of their construction, maintenance and removal, as well as the replacing of them as often as it may be necessary to fully carry out and complete the works connected with the enlargement of the canal.

It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering the works on the entire section must be embraced in the bulk sum stated in the tender.

Where the surface of the rock is not more than 7 feet below the water line, the face of the bank is to be protected by a dry wall built of large well-shaped stones of the best class that can be found in the excavation. It is to be two feet wide on top, increasing downward on the face at the rate of 2 inches to the foot—the back to be plumb and the coping stones to be of the full width of the wall (2 feet), are to be, when laid, one foot below the top bank. All the stones must be well bonded over and with each other, and the face of the wall made to range with the general line of the canal. In rear of these walls (if so directed) a space of 12 inches in width is to be made up for such a height as may be requested, with small stones, quarry waste or gravel, well rammed.

Where the surface of the rock exceeds a depth of 7 feet below the water line, the inside faces of the banks are to be protected in some one, or in any two, or it may be partly in each of the three following ways, as may be subsequently determined :—

1.—By a wall or covering of hand-placed "rip-rap" stone varying from thirty two inches in depth at bottom, to twenty inches in depth at top. The stone not to be of greater dimensions than can pass in every way through a square eight inches on the sides, except the bottom tiers, which are to be larger, and those on the top are to be laid level and form a moderately fair uniform coping not less than twenty inches in width.

All sharp angular points must be broken off the upper side of the outer stratum of stone, and the interstices between them must be filled with quarry waste, and the whole well pounded and beaten down to a fair surface.

2.—By a covering of pitched stone laid at right angles to the face, on about twelve inches in depth of quarry waste or gravel. The pitched stone to be in regular courses, varying from four to eight inches in thickness and from a depth of twenty two inches at the bottom part to a depth of sixteen inches at the top water line, laid throughout in coarse sand or in fine gravel, and have the joints in the respective ranges properly broken over and with each other.

The whole of the stones to be well rammed and beaten down to a fair uniform surface. To support the toe part of the pitched stone, an oblique or wedge-shaped timber is to be scribed and fastened with bolts one inch diameter let six inches or more into the rock, and where the bottom is clay or other material of that kind, the first tier of stones is to be let in its full depth and laid so as to form the toe support.

3.—A wall may be built of a like class of work as that previously described for places where the rock is not more than seven feet below the water line.

Contractors are requested to submit a price for each of these three different kinds of protection for the banks, subject to the distinct understanding that the work to be done may consist of all *three* kinds, or it may be of *two* of them, or wholly of *one* kind, without giving cause for any increase or diminution of the prices tendered for the respective items of work that may be performed.

To carry off the surface water that may collect in the ditch at the rear of the towing path and berme bank, drains 12 inches square are to be built of rubble masonry, covered with flat-bedded stones, the tops of which are to be from one to three feet below the surface of the bank.

BACK DITCHES—to carry off the surface water and such other natural drainage on the south of the canal as it may be necessary to provide for, are to be formed at the places and of the dimensions required, care being taken that the old

ditches are not interfered with or the drainage in any way interrupted before the new ditches are fully available.

For any damages that may arise from this cause, whether the result of inattention or otherwise on the part of the contractor, he will be held strictly and legally liable to the owners of the adjoining property.

To form an outlet from the ditches, wells are to be sunk in connection with them, from which off-take drains or culverts are to be made with such inclinations as will discharge water freely into the canal one foot or more below the surface level of the reach.

These wells will be from two to three feet square, and the culverts from them are to be from fifteen to twenty four inches square. They are to be built of rubble masonry laid in cement mortar; but the bottoms of both wells and culverts are to be of flat stones, of a size to reach across the respective openings and pass at least six inches under the walls on both sides; the covering of the culverts must also be of flat stones, of a length which will bear at least six inches on the side walls. All the excavation and work connected with the water-courses must be done by the contractor at the rates stated in the tender.

When conducting the works connected with the enlargement and deepening of the channel, as well as placing the material in the spoil banks, the contractor must be guided strictly by the lines marked out by the officer in charge. He must also take great care not to cut into the inside slopes nor do anything at all likely to have a tendency to impair the stability of the banks.

It is to be clearly and fully understood that the whole of the work to be done for the deepening and enlarging of the canal on this section (No. 8), will be measured, computed and paid for in the "solid." For this purpose, before the works are commenced, levels will be taken of all that portion of the ground to be removed over the water surface, and accurate soundings made (with reference to fixed and permanent bench marks), at short distances apart, along the whole length and breadth of the work. A duplicate copy of the cross sections, made from these levels and soundings, is to remain in the office of the Department of Public Works, another in the office of the Resident Engineer, and from these, together with the levels and soundings taken after the whole have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil banks, and in widening and deepening the channel and other cuttings, except absolutely connected "quarry rock" and detached stone or boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the cut and banks, forming and grading towing path, berme and ditches; trimming the sides of the cut to the required angle, bottoming the whole work and completing everything connected with the excavation in a workmanlike manner, agreeably to the foregoing specifications and directions of the officer in charge.

But as the price per cubic yard of each class of work will be an average of the whole of that particular class, payments will be made *only* according to the comparative value of the work done in reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in the manner following, viz:—

For rock excavation down to surface water of canal, *two-thirds* of contract price.

For rock excavation, from canal surface to three feet over bottom, *five-sixths* of contract price.

For the removal of the *three feet* above bottom line, contract price and proportion of balance, so that when the whole shall have been completed the aggregate shall be the same as if the whole were calculated at the prices stated in the contract.

During the progress of the work the different parts of the "earth" excavation will also be returned and paid for according to the comparative value of the work done with reference to the contract price.

Tenders will not be considered unless made strictly in accordence with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the due fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stock to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

☞ To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

☞ The works are to be commenced immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 25th day of April, 1878.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 16th February, 1876.

APPENDIX No. 44.

LACHINE CANAL.

RE-LETTING OF SECTION No. 9.

SPECIFICATION of the Work remaining to be done.

The works for which tenders are invited consist chiefly in the completion of the widening and deepening of that part of the Lachine Canal known as the "Rock Cut," commencing at a point about one thousand feet below the present guard lock and extending downwards 6,000 feet.

Work has been done (under a previous contract) at nearly all places on the line of the section; but at no place has the prism been completed, or the required capacity of the channel been obtained. Parties, when examining the locality and otherwise looking into this matter, should therefore bear in mind that the work is spread over the entire section, embracing the finishing up of all those parts where little, except trimming, remains to be done, as well as the completion of all other parts, whatever may be the quantity of material that still remains to be removed.

The channel is to be enlarged to a mean width of one hundred and fifty feet, and sunk to the depth of four feet below the top of the lower mitre sills of the present guard lock.

In rock cutting the side slopes are generally to be made one-fourth horizontal to one vertical, and in earth or clay the side slopes will in some cases be made to an angle of forty-five degrees; in others they will be made two horizontal to one vertical, if so directed.

The sides of the channel will generally correspond with the lines shown on the plan exhibited; but the Department of Public Works reserves to itself the right of changing

the whole or any part of the line to such an extent as will admit of widening the channel wholly, on either one side or the other, or of increasing the width on both sides, as may be subsequently determined.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution of the prices tendered for the respective items of work.

The greater portion of the material excavated can be deposited on some part of the section, at a distance of from one hundred and ten to two hundred feet from the centre line of the canal.

Contractors should, however, bear in mind that the spoil ground in some cases will not be opposite the places where widening is to be done, and that the haul of the material excavated below towing path level may at places be twelve hundred feet. This is especially the case at the upper end of the section, where there is no deposit ground opposite the cutting.

It should also be borne in mind that spoil banks have already been formed along the sides of the cut, which are at some places raised to a considerable height; consequently special arrangements must be made to elevate the material from the bottom, haul and place it where there is sufficient space within the limits of the canal property, on either side or both sides of the channel, as circumstances may require.

Spoil banks must be made wholly on canal property, and the material placed in such a manner as not in any way to encroach upon the back ditches or interfere with boundary fences. They must, on the inside, or side facing the canal, be formed with approved uniform slopes, and must, as near as possible, be made of a regular height, and where of a considerable width their tops must have a declivity outwards from the canal.

For the information of contractors, it may here be stated that all excavation, both of rock and earth, above the level of the towing path and berme bank, has been done; but the slopes have still to be trimmed, towing path and berme bank graded, and ditches at the foot of the slopes formed, all of which must be done by the contractor within the rates stated in his tender.

It may further again be stated that work has been done at nearly all places on the section; but that comparatively little, if any part of it, can be looked upon as completed, either as to the width or depth contemplated. Barely one-third of the actual deepening below the present canal bottom has been done, and there still remains fully 120,000 cubic yards of rock to be removed to make the channel of the width and depth required.

Towards this object, a series of holes two inches diameter and about 8 feet apart have been drilled to bottom or below it over all those parts where widening and deepening have to be done. These holes have generally been plugged, and for the most part are available for blasting purposes, except the range near the side of the cutting, the use of which for blasting will not be permitted, as heavy explosions in that position has the effect of shattering, or at least shaking the rock which forms the side of the cut.

Towing Paths.—At the places where the work connected with widening the prism is on the north side of the present channel, a new towing path of the full width must be continued and formed either as a whole or in part as may be required. It is to be made 18 feet in width and a like height as the present one, and have a ditch 2½ feet wide at bottom cut in rear of it, towards which the top shall have a

declivity of one foot transversely, and from the ditch suitable cross-drains are to be formed to carry off the surface water.

On the south side of the canal a berme bank is to be left or formed, and in either case graded at the height of 18 feet over bottom, made 12 feet wide on top, with a declivity outwards to a catch-water drain cut or formed at the foot of the spoil bank, from which suitable cross-drains are to be made, as stated for the towing path on the north side.

SLOPES.—The prism of the canal, as already stated, is to be excavated to a mean width of 150 feet, *i.e.*, between the bottom and surface water level of the canal. This is to be maintained in both rock and clay excavation, and the slopes made to the respective inclinations above mentioned. Where the widening is to be done through rock-cutting, the slopes are not to exceed *one-quarter* horizontal to one vertical. It is also to be clearly and distinctly understood that the contractor shall excavate and form to a like slope all other parts on both the north and south sides of the present cut, which are to form the sides of the enlarged canal, including the trimming of the sides of that part of the work executed under a previous contract. In every case all angular and projecting points of rock must be broken off, and the side slopes invariably trimmed to fair and uniform lines, corresponding to those marked out by the officer in charge.

For the entire length of the section and full width of the channel, the bottom must be sunk to an uniform depth of four feet below the top of the mitre sill of the present guard lock, or to a greater depth if rendered necessary by the thickness of the lower stratum of rock that has to be removed. The parts of the work done under a former contract must also be deepened where necessary, and in every respect made to correspond as above described with other parts of the completed channel.

Where earth, clay or sand is found to extend below the bottom line of the canal, it must, for the space occupied by the side wall, be removed to the depth of at least 6½ feet below the top of the mitre sill of the guard lock before the wall is commenced.

Where the surface of the rock is two feet or more below the level of the towing path, the face of the bank is to be protected by a dry wall, built of large well-shaped stones, of the best class that can be found in the excavation.

It is to be two feet wide on the top, increasing downward on the face at the rate of 2 inches to the foot—the back to be plumb, and the coping stones to be of the full width of the wall (2 feet) are to be laid one foot below the top bank. All the stones must be well bonded over and with each other, and the face of the wall made to range with the general line of the canal.

To carry off the surface water that may collect in the ditch at the rear of the towing path and berme bank, drains 12 inches square are to be built of rubble masonry, covered with flat-bedded stones, the tops of which are to be from one to three feet below the surface of the bank.

For the purpose of enabling the deepening of the channel and the widening of it below the water surface to be proceeded with, the canal will be emptied in the early part of December, 1878, and the water be allowed to remain out until the latter end of April, 1879.

The contractor's arrangements must, therefore, be such and his operations conducted in such a manner that the whole of the works on and connected with this section shall be done between the time of awarding the contract and the 25th day of April, 1879.

To accomplish this object the contractor must provide all necessary derricks, drilling machines, pumps, equipment for coffer dams, plant and tools required to urge forward the operations in an energetic manner, to the full satisfaction of the Minister of Public Works and his engineers.

Provision must be made by the contractor for thoroughly shutting out the water of the River St. Lawrence and laying the section dry. This may be done by constructing a dam at such place, above the upper end of the section, as may be approved of by the engineer in charge. The dam may be of crib work ballasted with stones, planked and puddled through the centre or on the upper side; or it may be formed in such other way as will be certain to effect the object of keeping back the water and at the same time can be readily removed. In the event of this course being adopted, another low dam will have to be formed a short distance further down, so as to catch any water that may pass through the main structures.

The water that may accumulate between the dams must be removed and discharged into the level above the lock by means of a pump of sufficient capacity, worked by a steam engine of power adequate to effect the object with certainty, and thereby prevent the leakage from flowing on to the section.

If, however, the contractor is prepared to show that he will adopt satisfactory and necessary precautions to effect the object, without endangering existing works, he may be allowed to shut off the water at the weirs on both sides of the canal and at the lock gates. But even in the event of this being consented to, a low dam will still have to be formed below the outlet from the weirs, and a steam engine and pump fitted up and worked so as to dispose of the leakage in like manner as above described in connection with the scheme for coffer dams.

For the purpose of removing the surface water, springs, leakage, snow, ice or any other accumulation of water on the section, one or more steam engines and pumps, of approved power and capacity, must be provided, delivered, equipped, fitted up and worked by the contractor.

The lower end of each pump must be placed at least 2½ to 3 feet below the bottom line of the canal, and suitable drains made to carry the water to them, the whole to be arranged in the most advantageous position to lift the water and discharge it into the River St. Pierre, or of disposing of it in some other way, without allowing it to pass on to the section below.

At the lower end of Section No. 9 a dam must be formed to prevent water passing on to or coming from Section No. 8, as well as to direct the water towards the pump.

Contractors should bear in mind that the respective items for coffer dams, pumps and machinery for unwatering this section should embrace the cost of their construction, maintenance and removal, as well as the replacing of them, as often as it may be necessary, to fully carry out and complete the works connected with the enlargement of the canal.

It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering the works, to the full extent above described, must be embraced in the bulk sums stated in the tender.

In all matters connected with the prosecution of the works, or in making arrangements for that purpose, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering

with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in widening and deepening the channel and other cuttings, except absolutely connected "quarry rock," and detached stone or boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing the materials, finishing up the cut and banks, forming and grading towing path, berme-bank and ditches; trimming the sides of the cut to the required angle, bottoming the whole work, and completing everything connected with the excavation in a workmanlike manner, agreeably to the foregoing specifications and directions of the officer in charge.

But as the price per cubic yard for each class of work will be an average of the whole of that particular class, payments will be made *only* according to the comparative value of the work done in reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in manner following, viz. :—

For rock excavation below level of towing path to bottom of present canal, *four-fifths* of contract price.

For the removal of the *three feet* above bottom line, contract price and proportion of balance, so that, when the whole shall have been completed, the aggregate shall be the same as if the whole were calculated at the prices stated in the contract.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signatures, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required by deposit of money to the amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as for the due performance of the works embraced in the contract.

Immediately after the person or persons whose "Tender" has been accepted shall have entered into contract, arrangements must be made for providing all necessary engines, pumps and derricks, and other plant, all of which, together with the material required for the coffer dams, etc., must be delivered in the vicinity of the works on or before the 15th day of November next, and such proparations made to facilitate the operations as will fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 26th day of April, 1879.

Tenders will also be received for the full and satisfactory completion of the works under the condition of the contractor being allowed the months of March and April of each of the years 1879 and 1880, or in the aggregate four months for that purpose. This

would, of course, necessitate the construction and removal of the dams two different times, at both the upper entrance of the canal and lower end of the section, *i. e.*, the construction of dams in February, 1879, and their removal in the latter end of April of that year, also the construction of dams in February 1880, and their full and complete removal by the latter end of April of that year. Steam engines and pumps would also have to be twice placed and twice removed, and it is probable that there would be a greater extent of actual pumping required. It would also necessitate the collecting and organizing a force of men at two different times. These various important matters should be duly considered by parties offering to undertake the execution of the work.

JOHN PAGE,

Chief Engineer of Public Works.

OTTAWA, 9th September, 1878.

APPENDIX No. 45.

LACHINE CANAL.

SPECIFICATION of the Work to be done on SECTION No. TEN of the Enlargement.

This section is on the south of the guard lock and weir at Lachine, and is about 1,400 feet in length between the boundary stakes planted at its upper and lower ends. It includes all the works connected with the formation of a new channel for the distance above stated, the construction of a new guard lock (gates excepted), abutments for a swing bridge, etc.

The canal will, for the most part, be located as shown on the general plan exhibited —the centre line corresponding nearly with that marked out on the ground, but the Department of Public Works reserves to itself the right of changing the whole or any part of the line as much as fifty feet either to the right or to the left of that represented, and of altering the position of the lock and bridge one hundred feet either upwards or downwards from that indicated on the plan. These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced, or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The canal will generally be made one hundred and fifty feet mean width between surface water line and bottom; above the new lock it will be sunk to the depth of six feet below the top of the mitre sills of the present guard lock; below the new lock the bottom will be left two feet higher or sunk four feet below the top of the sills of the present guard lock.

In rock cutting, the side slopes are generally to be made *one-fourth* horizontal to one vertical, and in earth or clay the side slopes will in some cases be made to an angle of forty five degrees, in others they may be made one and a half horizontal to one vertical.

All angular and projecting points of rock on the sides of the cut are to be broken off, and the side slopes in both earth and rock excavation must be trimmed off to fair and uniform lines, corresponding to those marked out by the officer in charge.

When proceeding with the works, a sufficient quantity of suitable clay and earth for embankment behind the lock walls and bridge abutments must be saved and piled at a place or places convenient to where it can be used for the purposes mentioned.

All the other earth, clay, old spoil bank and rock excavated from the prism of the canal and lock pit must be hauled beyond the upper end of the section and deposited in the river in a continuous line upwards.

The bank thus formed is not to exceed thirty feet in width on top when carried to the height of the present pier, and it must be arranged so as to be close up to, but not in any way interfere with, the southern line of Section No. 11 or the contemplated new harbor works.

In forming it, care must be taken to place the stones from the excavation along the outer or river side of the bank, so as to prevent, as much as possible, the current and action of ice cutting into or destroying it.

Contractors, when tendering, should bear in mind that the material from all parts of the excavation of both the channel and lock pit (except what is required for embankment in the rear of the walls) is to be used for making and extending a bank of the dimensions above described, *i.e.*, the bank will be carried or extended as far up stream and parallel to the new entrance works as can be formed from the whole material excavated on the section. The cost of handling, hauling and depositing the material in the manner stated, or as may be directed, together with all the expenses connected with forming this continuous bank, must be embraced in the respective prices tendered for excavation.

The contractor, during the prosecution of the works, must invariably be guided by the levels given and the lines marked out by the engineer or officer in charge.

None of the stone found in the excavation will be allowed to be used for building purposes in connection with any of the permanent structures.

The seat of the embankments in rear of the lock walls and bridge abutments must be fully cleared of all loose stones or other objectionable materials, and be prepared in the manner required by the engineer, or foreman of works, whose approval must be had and obtained before an embankment is commenced. The material must then be hauled on to the respective banks in carts or waggons, and laid on in layers not exceeding nine inches in depth at a time; and if the work be done at a dry season of the year, water must be thrown over the banks to assist in consolidating them.

PUDDLE BEDS—when necessary to be made in any of the banks, must be carried up at the same time as the banks are formed. They must be made of the best description of material for that purpose that can be obtained in the vicinity, laid on in layers not exceeding eight inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done that may be required to form them into puddle walls impervious to water.

There are to be only two classes or denominations of excavation recognized, namely, "earth" and "rock;" the former to embrace all kinds of materials found in the old spoil banks and other excavation on the section, except absolutely connected "quarry rock" and detached stone or boulders containing one-third of a cubic yard and upwards.

The prices tendered for these items to cover the entire cost of removing the materials, and, as previously stated, forming the range of river bank on the south side of the new entrance channel, finishing the prism of the canal, forming embankments and completing everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specifications.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done, with reference to the prices tendered, which *pro rata* rates shall be assigned and apportioned in such a manner that, when the whole work shall have been executed and completed, the aggregate amount shall be the same as when the respective total quantities are calculated and extended at the prices stated in the contract.

GUARD LOCK—to be 270 feet in length between the gate quoins, 45 feet in width between the side walls at the level of the lower reach, and the bottom of it must be so arranged that the top of the mitre sills shall be five feet lower than those in the present guard lock.

It will be constructed of dressed stone masonry, laid in hydraulic cement mortar, placed upon a foundation prepared as herein described, and the upper wings of it will be extended to form bearings for a swing bridge to carry the travel of what is called the lower Lachine road.

The pit and foundation for the structures to be made of suitable dimensions to admit the side walls, recesses, wings, etc., and to correspond with such lines as will be marked out by the officer in charge; the upper or earth portion to have such slopes as may be required for the stability of the banks during the building operations.

In the lower or rock portions of the pit the sides are to be made perpendicular, and a space of one foot left for concrete in rear of the walls.

The material excavated from the lock pit must, as before stated, be hauled and placed so as to extend the bank to be formed on the lower or southern side of the new entrance channel.

If solid and suitable rock, in thick layers, is found at the proper level, at the place where the lock is to be built, the walls will be commenced upon it; but if the rock be unsound, the fissures in it numerous, or the strata be thin or irregular, a floor of pine timber covered with 3-inch pine plank will be laid at a height to form a bearing surface for the walls.

In the latter case the FOUNDATION TIMBERS are to be of pine, 12 inches square, of the full length to reach across the chamber and space to be occupied by the walls on both sides; but occasionally two timbers may be used to make up this distance, one of which must, however, extend from the rear line of one wall and across the chamber to 18 inches under the front edge of the wall on the opposite side.

They are to be laid 9 inches apart through the chamber, 6 inches apart above the mitre sills, and at the lower end of the lock; they must be scribed to the rock, and placed on a bed of mortar or of concrete, as circumstances may require. The spaces between them must, immediately after they are satisfactorily laid, be filled with concrete well rammed, and their tops must be dubbed to an uniform surface, to afford a fair bearing for the plank.

MITRE SILL PLATFORMS—to be 14 feet in width, made up of timbers 12 inches square, and of a length to reach from rear to rear of the

walls, all of which must be counterhewn, well jointed with a plane, so as to make water-tight joints for their entire length and depth. They are to be secured by five wrought iron screw-bolts (1½ inches diameter) passing horizontally through the platform.

Both ends of each of the three middle bolts must have double nuts and washers, in order to form a connection with shackle-bolts that pass down into the rock and are secured in such a manner as may be directed.

The joints throughout must be well caulked with at least two threads of oakum, and every precaution adopted to render the whole water-tight.

The platforms are to be laid throughout in a full bed of mortar and secured to the rock with fox and key-bolts, and at the outer edge, on both sides, will be connected with a stop-water timber let into the rock.

STOP-WATERS.—If the rock underneath is sound, instead of sheet piles at the upper and lower sides of the mitre sill platforms, checks are to be cut in the rock 4 inches or more in depth and 12 inches wide, extending across the whole width of the foundation, into each of which must be fitted a timber 12 inches wide, and of sufficient height to form a close joint with the outer timbers of the platform. Before a stop-water is placed in its berth, a piece of duck or canvas, well saturated with white lead, must be laid for the full length and width of the check; the upper timber must also be embedded in white lead, and the whole secured to the rock with fox and key-bolts, 1¼ inches diameter, placed not more than 10 feet apart.

Stop-waters, similar to those above described, are to be placed at the upper sides of the recesses.

If the rock is sound and of a durable nature, at the level necessary to afford an uniform depth of 6 feet below the top of the mitre sill of the present guard lock, no timber will be used for a chamber floor.

FLOORING.—In the recesses, and where required, two courses of pine plank are to be laid; the first 3 inches in thickness, and the second 2 inches thick. They are all to be jointed with a plane, and when being laid must be driven up to water-tight joints; every three feet in width of planking, in both courses, must break joints at least 4 feet; and the upper course must in all cases break joints both lengthwise and transversely with the one underneath.

The lower course to be fastened with white oak treenails, 9 inches long and 1½ inches diameter, two in each end of a plank and one on alternate sides at every crossing of a timber; it must be dubbed to an uniform surface before the second course is laid—the latter to be fastened with pressed spikes, two at each end of a plank and one at each crossing of a timber, on alternate sides of the plank.

In case it becomes necessary to lay a timber foundation through the chamber, either as a whole or in part, only one course of flooring plank will be used.

MITRE SILLS—to be of the best description of white oak timber, properly squared and dressed with a plane. They are to be framed, mortised, tenonned and secured in the manner shown on a detailed plan to be furnished.

The main sills are to be 49 feet long, let 2 feet into the wall at each end; they, as well as the braces, must be of a size to stand 19 x 19 inches when dressed. The mitre sills are to be 19 x 19 inches, checked 3 inches into the platform timbers, and are to be

tenonned into each other at the mitre, and at the toe tenonned and boxed into the main sill. A check 3 inches deep is to be cut in the lower edge of the mitre sills, to receive the ends of the first course of planking. Before they are put together, all the mortises, tenons and joints must be well coated with white lead; and, when about to be placed in their berths, a strip of canvas, well saturated with boiling tar, is to be placed in the check formed in the platform, into which the mitre sills are to be embedded.

The mitre and main sills are to be connected by straps of wrought iron, $3\frac{1}{2}$ inches wide and five-eighths ($\frac{5}{8}$) of an inch thick, let in flush, fastened with bolts, and arranged as shown on plan. The holes through them must be punched so as to retain the full strength of the iron; the bolts are to be one inch and a half ($1\frac{1}{2}$) diameter, have upset heads—one-half of them to be 2 feet 4 inches long and well ragged at the point—the other half to be 3 feet or more in length, fox-wedged and let into the rock under the platform.

MASONRY.—The side walls of the new lock will be commenced as near to the level of 6 feet below the top of the mitre sills of the present guard lock as circumstances will permit, and be carried to about the same level as the latter or to a height of 23 feet 8 inches.

The chamber walls are to be 9 feet wide at bottom, with counterforts in rear, 6 feet long in line of wall and 3 feet projection, placed not more than $12\frac{1}{2}$ feet apart; the recesses are to be 2 feet 8 inches deep at top, $9\frac{1}{2}$ feet wide at bottom.

The face of the chamber and wings is, throughout, to have a batter of *one* in *twenty-four;* but the recess walls are to be carried up plumb on both front and rear, except for a distance of about 28 feet in the centre, where a frost batter will be formed.

The back of the chamber and wing walls will be carried up plumb to within 5 feet of the top, thence batter to the rear line of the coping, and the counterforts will terminate within 5 feet of the top of the coping.

All the masonry of the lock must be of approved, sound and durable stones; those forming the face work must be of the best class of gray limestone, free from drys, seams or other defects, and must be at least equal in every respect to the best of the stones used in the present guard lock at Lachine.

The face stones must be of an uniform texture and color and laid in regular courses; the ashlar work may vary from 12 to 30 inches in height, the thickest courses invariably to be placed at the bottom, and diminish upwards in regular succession to the course under the coping; but when a course of cut stone exceeds 18 inches in height, the face of the chamber may be made up of two courses of stones of equal height.

From the lower end of the lock to 6 feet above the recess quoins, and from the head to 12 feet below the hollow quoins, the face work is to be of cut stone, dressed and laid so that the beds and end joints shall not exceed three-sixteenths of an inch.

The chamber walls between the points above mentioned are to be faced with a good description of coursed boucharded work (coping excepted), laid so that the beds and end joints shall not exceed three-eighths of an inch.

CUT STONES—to be neatly dressed and boucharded, made square, bevelled or otherwise suited to the positions they are to occupy in the work. Their arrises must be kept good, their upper and lower beds made parallel and their end joints in all cases kept full for at least two-thirds the depth of their beds.

The back part of the stones must be hammered or picked off to such lines that the backing stones, when laid, may form with them joints not exceeding one inch in width.

The face stones to consist of headers and stretchers, the latter to be at least 3 feet long in line of wall and not less than two and three feet depth of bed in the alternate courses. In each course must be headers of at least two feet length of face and $4\frac{1}{2}$ feet depth of bed, placed not more than eleven (11′) feet apart from centre to centre. The headers in each course are to be arranged as nearly as possible mid-way between those in the course immediately below.

No two vertical joints in adjoining courses are to be nearer each other than 12 inches, and care must be taken that the bond in rear of the face stone is properly formed throughout.

When the face stones are over 24 inches in height, the depth of bed of the stretchers in the alternate courses must be at least $1\frac{1}{2}$ times their height, and the headers $2\frac{1}{4}$ times their height, and in all cases the tail of a header must have a width of two-thirds ($\frac{2}{3}$) the length of its face.

Hollow Quoins—to be alternately headers and stretchers, the former at least $4\frac{1}{2}$ feet face and $5\frac{1}{2}$ feet depth of bed; the latter $5\frac{1}{2}$ feet face and $4\frac{1}{2}$ feet bed in the top courses, increasing in dimensions downwards at a rate suited to the batter of the wall. The headers are to be checked so as to bond at least one foot over the face stones of the recess. The nose of the quoins to be rounded, the radius gradually increasing downwards at a rate corresponding to the batter of the wall; the hollow to be dressed out true and smooth to a radius of 8 inches, from which the heel is to run off obliquely to the line of the wall. Patterns for the hollow quoins will be furnished by the engineer, after the contractor has given the height of the courses he intends to use.

Recess Quoins—to be also $4\frac{1}{2} \times 5\frac{1}{2}$ feet, and $5\frac{1}{2} \times 4\frac{1}{2}$ feet, laid alternately out-bond and in-bond, bevelled, as shown on plan; the headers to be checked so as to make return-bond with the ashlar of the recess.

Chain Wells and Man-Holes.—There are to be eight chain wells in the position indicated on the plan; each well will be two feet square inside, and the man-holes from them to the front of the lock walls are to be made at the angles and widths to permit the play of the chains, and of such height as the engineer may direct.

The sills and lintels to be of stone sufficiently large to reach across the opening and one foot on each side; the bottom to slope towards the inside of the lock, so as to prevent the chain when slack lodging in the man-holes; sheaves for the drag chains are to be inserted and secured near the upper inner angles of the man holes. The face stones of the wells and man-holes to be of like dimensions, and cut in like manner as the face walls of the recess, and are to be properly bonded over and with each other at the angles.

Checks.—For the reception of stop-water timbers, two checks are to be formed in the face of the wings at both ends of the lock; they are to be arranged as shown on plan, be 2 feet apart, 12 inches wide and 6 inches deep at the top, and made plumb in the rear.

Coursed Work—for the face of the chamber walls may be 9 inches high and upwards, but a course once commenced must be continued the same height throughout, and in no cases will more than two courses be allowed to make up the height of one course of cut stone. They must be at least 20 and 30 inches depth of bed in the

alternate courses, and have not less than 2 feet length of face in line of wall. In every course there are to be headers of at least 20 inches length of face and 4 feet depth of bed, placed not more than 12 feet from centre to centre.

In all cases the rear part of both headers and stretchers must be at least two-thirds the length of their face.

The face of the stones must be dressed to the batter of the wall, boucharded and the arrises kept good. The upper and lower beds must be made parallel for their entire depth, and the end joints kept full for at least 9 inches back from the face. The whole to be dressed so that the horizontal and vertical joints of the stone, when in place, shall not exceed three-eighths of an inch.

BACKING—to be of an approved class of large, well-shaped stones not less than 6 inches in thickness and 4 feet area of bed, laid level in full mortar beds and properly bonded throughout the wall; where the depth of the face stone equals or exceeds 12 inches, two thicknesses of backing may be used, provided their joint depth does not exceed that of the face work.

The lower beds, if necessary, must be picked off so as to insure an uniform and equal bearing on the course below. No pinning will be permitted.

The edges of all thin wedge-shaped stones must be broken off so as to be at least 6 inches thick, but if the bevelled part still exceeds one-fourth the area of the stone, it must be still further reduced. After this has been done, the stone laid and the vertical joints properly grouted up, the oblique portion may be brought to a level for the next course.

The backing stones must in all cases be laid on their broadest beds, and the stone against a face header must occasionally extend to the rear line of the wall. The black limestone used for ordinary building purposes in Montreal will not be allowed in the work.

COPING STONES—of the chamber, recesses and wing walls are to be 4 feet wide on top, increasing in width downwards to the frost batter in the rear and to the face batter of the walls, except in the recesses, where the face will be plumb. They are to be at least 15 inches in height of course, and not less than 4 feet long in line of wall.

Coping of a like height, but for the most part in larger pieces, will extend over the buttresses for the chain wells, for the arrangements of which, as well as for the quoins, a detailed plan will be furnished.

The lower quoin coping must, however, be at least 6½ feet square on top and 2 feet depth of bed.

The lower bed and joints of each stone must be kept full, the upper bed and face neatly dressed and the inner top arris rounded off to a radius of three inches. The whole to be laid so that the horizontal and vertical joints shall not exceed ¼ of an inch.

A dowel, 4 inches long, 1½ inch iron, to be inserted in every joint 15 inches back from the face and 6 inches from the top.

CHECKS—for the reception of stop-water timbers are to be formed on the face sides of the lower wing walls and above the guard gate, two on each side of the channel way at the respective places; they are to be 2 feet apart, 12 inches wide and 6 inches deep at the top, and made so they can be carried up plumb in the rear.

BRIDGE SEAT, GUARD GATE, ETC.—To form bearings for a swing bridge, walls are to be extended upward in continuation of those of the lock, in which recesses are to be formed and other arrangements made for a guard gate, such as will occupy a horizontal position when not in use, and stand vertically when required to shut off the water.

These walls are generally to be made 9 feet wide at bottom and have a face batter of one in twenty four; they are to be curved at the upper end and be of the respective lengths, shapes and dimensions represented on the general plan..

They are for the most part to be of a like class of masonry, laid throughout in hydraulic cement mortar, as described for the chamber walls of the lock; the whole to be arranged, recessed, curved and otherwise adapted for the toe and heel as well as for the turntable on which the bridge is to move, and all other work connected with the masonry done that may be required to carry out efficiently and satisfactorily the contemplated design.

The foundation of the wall for carrying the heel track of the bridge is to be at least six feet below the surface of the embankment in rear of the lock wall, and that part of the foundation for the seat of the turntable north of the side wall is to be laid at 8 feet below the top of the lock coping, and must be formed either of timber and plank or a stratum of concrete, as may be directed.

The coping stones are to be at least 15 inches in depth; on the side walls or extension of those of the lock they are to be 4 feet in width on top and those on the turntable pier must be from 4 to 6 feet in width, according to their position, so as to form a circle to support the track for the rollers. They must all be full bedded throughout and dressed so as to lay to joints not exceeding one-fourth of an inch, and the top must have a fair surface, be neatly boucharded and, where required, the outer top arrises are to be rounded off.

The pivot-stone to be not less than 6 feet square and 2 feet depth of bed; the space between it and the outer range of coping must be filled in with stone the same thickness as the latter, properly dressed and jointed to the width and be at least $3\frac{1}{2}$ feet in length.

The descent from the lock wall coping at the lower end on both sides is to be made by means of a flight of steps not exceeding nine inches rise, cut out of the solid, for the full width of coping, treads to be of an uniform width of at least 12 inches.

A flight of steps $2\frac{1}{2}$ feet in length is also to be cut out of the solid to form a side ascent to the bridge at both ends and on both sides.

At all the four corners of the bridge, circular parapet walls are to be built and piers carried up; these walls are to be of cut stone and all the workmanship and materials connected with them must be of the best class.

GUARD GATE.—At about 40 feet above the upper quoins of the rock, a recess is to be made in both of the side walls, as well as in the bottom, for a guard gate. This gate is to be so arranged as to occupy a horizontal position below the bottom of the channel when not in use, and to stand vertically when required to shut off the water. The recesses in the walls are to be 20 feet in length, parallel with the channel and are to have quoins of like dimensions, arranged in a similar manner as described for those connected with the recesses of the lock.

For 2 feet above and 3 feet below the vertical lines of the recesses in the side walls, or for a distance of 25 feet, the bottom is to be sunk 4½ feet lower than that of the channel for at least 3 feet beyond the face lines of the walls on both sides. On the bottom of this horizontal recess, ranges of pine timber of the full length to extend at least 18 inches under the side walls are to be laid 12 inches apart upon full beds of cement mortar, and the spaces between them filled with concrete.

At the up-stream side of the recess, a wall of timber 2½ feet or more in thickness is to be carried up to the height of the bottom of the channel and connected with a stop-water timber let into the rock underneath and secured as described for the stop-waters at the mitre sill platforms. The timbers forming this wall must be dressed and jointed with a plane, be fastened to each other horizontally with screw-bolts, and vertically to the rock underneath with such a number of fox-wedged bolts of 1¼-inch iron as may be directed at the time when this portion of the work is in progress.

At the lower or lock side of the recess, a platform of dressed and well-jointed oak timber of at least five feet in width is to be laid at a few inches below the bottom level of the channel, the timbers of which are to be secured to each other with three or more bolts 1½ inches diameter passing horizontally through them, the ends of the bolts to have double nuts and washers and be connected with shackle-bolts passing down into and secured to the rock.

The breast of the recess is also to be of dressed and well-jointed timbers of a height to make up the space between the bottom of the recess and lower side of the platform.

The lower timber of the breast is to be checked to receive the ends of the plank with which the bottom of the recess is to be floored, and the lower timber of the platform is to be checked to receive the ends of the floor plank of the lock recess.

The timber on the up-stream side of the platform must be of the best description of white oak, 18 x 20 inches, and is to have the up-stream upper edge hollowed out for the gate as shewn on plan.

All the timber of the platform, breast and recess must be of sufficient length to reach across the channel-way and pass at least 18 inches into the walls on both sides.

The space under the platform and between it and the breast must be filled with concrete and everything done to render the whole water-tight.

In the event of it being subsequently determined to form the upper breast of masonry, a larger space must be excavated for it, and the wall must be built of large blocks of stone laid on the top of the recess floor and carried up to within a few inches of the channel-way.

MORTAR.—The whole masonry of the locks and other structures above described must be laid in mortar made of the best hydraulic cement, mixed with clean, large grained, sharp sand, generally in the proportion of two of sand to one of cement, or such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and until used must be protected from the influence of the weather in suitable buildings provided by the contractors. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about one and a half of clean, sharp sand to one of cement and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

When the works are in progress, the walls must be kept free from all improper materials, and both the face stones and backing must be well washed if clay or other soil adheres to them, and in warm weather the beds and joints of the stone must be moistened with water before they are laid.

In case the walls or any portion of them are allowed to remain in an unfinished state over winter, the contractor must cover them in such a manner as will thoroughly protect them from the action of frost.

Contractors should bear in mind when tendering, that black limestone, such as used for ordinary building purposes in Montreal, will not be allowed in any part of the work connected with the section.

CONCRETE,—where used, must consist of an approved quality of stone, broken to cubes of $1\frac{1}{4}$ inches, thoroughly mixed with fresh hydraulic cement and clean, sharp sand, in such proportions as may be required.

ORDER OF BUILDING.—The walls are to be carried up in such a manner as not to have more than two unfinished courses at one time, and so that one wall shall not be carried up more than one course higher than the other.

The stones must be prepared for the respective places they are to occupy in the work before they are brought on to the walls; and all the vertical joints of one course are to be properly grouted up before another course is commenced.

Suitable derricks or other approved machinery for handling and laying the stone must be provided by the contractor, and every precaution adopted to guard against disturbing the stones after they are laid.

From the foundation up to the top of the rock, the spaces between the walls and sides of cut are to be filled with concrete, or so much of them as may be directed.

PUDDLE BED—in rear of the lock walls to be 3 feet in width, carried the entire height; it must be made of the best description of material that can be obtained in the vicinity, laid on in layers not exceeding 8 inches in thickness, each of which must be watered, properly cut transversely and longitudinally, well trodden and pounded, and everything done to render the whole impervious to water. Puddle beds where required at other places are to be made in a similar way, and of such dimensions as may be directed.

The embankments at the back of the walls, made up in the manner before described, are to be at least 25 feet in width, and have a declivity of 6 inches outward from the lock, to such ditches as may be required to carry off the surface water.

The superstructure of the swing bridge, also the machinery required for working it, as well as the lock gates, will be made separate contracts; but all the masonry required to be done on the section is to be built by the contractor for the lock.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in making arrangements for these purposes, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such may result from a desire to prosecute the works, inattention or any other cause.

Before the existing roadway which passes through the section is obstructed or in any way disturbed, the contractor must provide, at his own cost and expense, satisfactory means for the public travel to pass freely at this place, either by the construction of a temporary bridge, or some other way, by which the general travel will be accommodated. It is further to be clearly and distinctly understood that he (the contractor) shall be held strictly and legally liable and responsible for keeping the crossing in such a condition that it can be safely used during the whole time the work in progress, and that he will remove, at his own cost, when directed, any bridge or temporary means of crossing that may have been left or formed.

It is further to be clearly and distinctly understood that the contractor for this section shall give every facility, that the engineer in charge may consider reasonable and fair, in the way of access to Section No. 11.

Parties tendering are especially requested to bear in mind that all the works of excavation on this section must be proceeded with during the present winter, and that arrangements must be made for carrying them on in an expeditious and satisfactory manner as soon as the person whose tender has been accepted shall have been notified to that effect by the Department of Public Works.

The bulk sum tendered for unwatering the works must embrace the cost of constructing all coffer-dams required to keep out the water of the River St. Lawrence, as well as that of the present canal, and to guard against leakage, springs or surface drainage, together with the expense of pumping, baling, removing ice and snow, and every contingency directly or indirectly connected with unwatering the lock pit and adjoining reaches of the canal, during the progress of the operations, and up to the full completion of the whole undertaking, and the satisfactory removal of all coffer dams and other temporary works.

Detailed Plans.—The plans exhibited are only intended to show the comtemplated arrangements and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality, and for all such parts of the structures as may be required, will be furnished as the works proceed.

The contractor must provide, at his own cost and expense, all the service ground that may be required for temporary roads, or for placing and preparing materials beyond the limits of the unoccupied canal lands adjoining the section.

He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipments, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their

purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works, as herein described, and the instructions that may from time to time be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms, and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate, or by deposit of money, public or municipal securities, or bank stock to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions as well as for the due performance of the works embraced in the contract.

The works connected with the excavation of the lock pit and section are to be commenced immediately after the person or persons whose tender has been accepted shall have been notified and directed to do so by the Department of Public Works, and must be proceeded with in an expeditious manner, such as will satisfy the Minister of Public Works that energetic efforts are being made to do as much of the work this winter as can possibly be done, and the rate of progress in other respects must be such as to satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the 25th day of April, 1878.

JOHN PAGE,
Chief Engineer of Public

OTTAWA, 3rd January, 1876.

APPENDIX No. 46.

LACHINE CANAL.

SPECIFICATION of Work to be done for the formation of new ENTRANCE CHANNEL and BASIN at LACHINE, SECTION No. ELEVEN.

The entrance to the enlarged canal is to be on the south-eastern or river side of the channel at present in use. It is to be formed by a continuous line of pier work about 6,200 feet in length, placed for the most part in the position indicated on the general plan exhibited; but the Department of Public Works reserves to itself the right of changing the whole or any part of the line *three hundred feet* either to the right or left of that represented, or for such other distance, in either direction, as may be considered advantageous for effecting the object contemplated.

These changes, it is to be clearly and distinctly understood, may be made either before the works are commenced or during their progress, without giving cause for any increase or diminution in the prices tendered for the respective items of work.

The channel is to be made two hundred feet in width, and sunk uniformly to the depth of six feet below the top of the mitre sills of the present guard lock.

Contractors when tendering for this section should bear in mind that, except for a short distance at its lower end, the whole area occupied by the works upon it is in the river, and at some places strong currents must unavoidably be encountered.

As the material to be removed, except near the bank of the river, consists for the most part, if not wholly, of rock in position, arrangements are to be made with a view of enabling a large portion of the space to be unwatered, so that if possible the bulk of the excavation may be done in the usual way.

To effect this object, about 3,600 lineal feet of the pier from the bank of the river upwards is to be formed of two ranges of cribs each 15 feet wide, placed 6 feet apart; this

space must be properly cleared out, be lined with deals and filled with the best description of puddle.

Within a distance of 120 feet above the place where the double crib work terminates, the width is gradually to diminish to 30 feet, and continue at that width to the lower side of the ice-breaker that is to form the head of the pier.

The superstructure to be carried to about the same height as the coping of the guard lock, for 600 feet at the upper end it will be of pine timber and at all other places it is to be of stone hand laid and faced wholly on one side and partly on both sides with masonry built in cement mortar.

A dam is to be built across the water-way near Station No. 415, which is to connect with a puddle wall supported by a line of rough crib work sunk alongside the south-easterly side of the old pier, from the place mentioned inwards to the bank of the river, etc.

All the works to be executed in the manner herein described and at the time required by the Department of Public Works.

CRIB WORK—to be of the full width above stated for the respective places and in lengths of at least 30 feet. The side and end timbers must be 12 inches square and invariably be straight, sound and full on the edges for their entire length.

FRAMING.—The outer or face timbers on both sides of the cribs must be framed and laid so that the horizontal joints between the different courses shall be close for at least two-thirds of their length, and at no place exceed one-half ($\frac{1}{2}$) an inch. At the angles they are to be connected by double-bevelled dovetails arranged so that every end timber shall be dovetailed into two side timbers, and the side timbers be similarly placed between those forming the ends. At each corner in every course a rag-bolt 12 inches long and five-eighths ($\frac{5}{8}$) of an inch diameter is to be driven through the dovetail.

CROSS TIES—to be of flatted timber 10 inches thick, of a sufficient size to square 10″ x 11″ inches at both ends and of the full length of the outside width of the cribs. They are to be placed not more than 10 feet apart and so arranged that the ties resting on the different rounds of timber shall be mid-way between those of the courses immediately below and above. Their ends are to be dovetailed 4 inches into the timbers under and over them, and have a square shoulder of 1 inch on both the upper and lower sides. The dovetail to splay $1\frac{1}{2}$ inches on each side, so as to stand 8 inches at the neck and 11 inches at the outer end.

A rag-bolt 2 feet long, seven-eighths ($\frac{7}{8}$) of an inch diameter is to be driven through the head of each tie, passing through the course on which it rests and into the course below.

LONGITUDINAL TIES.—In all the cribs above the water-tight part of the pier longitudinal ties 10 inches thick are to be framed into and dovetailed between the alternate tiers of end timbers and be secured by bolts of similar dimensions and in like manner as described for the transverse ties. They are to be notched into the cross ties and fastened at the crossings by means of white oak treenails 2 inches diameter and 16 inches long.

In the cribs forming the head or termination of the pier there must be longitudinal ties in every course, placed alternately 10 feet and 20 feet on the outer sides.

The cribs are to be further secured by vertical ranges of binders placed inside and extending from the lowest side timber up to the water line. There are to be three ranges on a side, *i.e.*, one at or near each angle and another in the centre, making in all six vertical ranges in a crib, and to afford a fair bearing for which the side timbers must be "spotted."

The binders are to be of plank 4 inches thick and 10 inches wide, fastened from the inside by 10-inch spikes five-eighths ($\frac{5}{8}$) of an inch diameter, two driven through each plank into the lowest side pieces or that on which the ballast floor rests, and one at every crossing of a side timber from the floor upwards. They may be put on in lengths of from 8 to 10 feet or more, but they must be so arranged that the upper length shall in all cases reach down at least 18 inches lower than the top of the plank of the same range, and care must be taken to have their top and bottom ends well fastened.

BALLAST FLOORS—to be of flattened timbers 10 inches in thickness for all the cribs above the water-tight part of the pier and of the full length to pass through the respective cribs. They are to be laid transversely from eighteen to twenty-four inches apart, or such other less or greater distance apart as circumstances may require, and rest on either the first or second course of side timbers as may be directed, and to which, each piece at both ends, is to be fastened by a rag-bolt three-fourths ($\frac{3}{4}$) of an inch diameter and 18 inches long. When considered necessary to place the ballast floor on the second course of side timbers there must be two or more longitudinal pieces dovetailed into and secured to the end pieces at the proper height to form bearings for the floor.

The cribs, from the bottom upwards to low-water line, may be formed either of pine, oak, elm, ash or tamarac timber; but whatever kind is used, it must be of the full dimensions, straight and of good quality, free from shakes, sap-wood, unsound knots or other defects.

Before a crib is put together, the contractor must in all cases take correct close soundings over the place it is to occupy when sunk, and any boulder stone, or abrupt irregularities found within range of the pier must be removed, hollows or deep depressions of less width than 20 feet on same line must be carefully filled and levelled up with stone, under the supervision of a *Diver* employed by the contractor for that purpose, and when irregularities are of a nature that they cannot be removed, the bottom of the crib must be adapted to them, so that when placed in its berth, the sides and ends shall be plumb, and the whole form a line corresponding to that marked out by the officer in charge.

Immediately after a crib has been moored in the right position, the contractor must lay a platform of plank over it, of sufficient size and strength to carry stone enough to sink it, and when sunk and ascertained to be in the proper line and place, the crib is to be filled with an approved class of moderate-sized stone, packed as closely as possible.

From the water-tight part of the pier upwards, the top of the crib work is to be kept as nearly as practicable at a height corresponding with 9 feet water on the mitre sill of the present guard lock.

As previously stated, 600 feet at the upper end of the pier is to be of timber work filled with stone, carried up to a like height as other parts of the line, and built in manner following:—

SUPERSTRUCTURE—to have a batter of one in twelve on the face; built of pine timber 12 inches square, generally in pieces not less than 40

feet long, or of such other lengths as will break over and upon the different cribs. They are to be scarfed at the end where they connect; the scarf to be square at heel and toe, and have a lap of 18 inches, with a block underneath, and be secured with a bolt 18 inches long and three-quarters ($\frac{3}{4}$) of an inch diameter.

The timber must be counterhewn if required, and laid so as to leave a space of one inch and a half between the courses. The top tier on both sides to be rebated to receive the ends of the covering plank, if so directed.

TRANSVERSE TIES—of flattened pine timber, of a size to square 10 x 12 inches at both ends, and of sufficient length to extend across the pier are to be placed in every course, not more than 10 feet apart. Their ends are to be dovetailed $3\frac{1}{2}$ inches into the side pieces under and over them, in like manner as described for the cribs.

Under the head of each tie, at the joint between the courses immediately below it, a block 2″ x 11″ x 11 inches is to be inserted to give an uniform bearing, and a rag-bolt $2\frac{1}{2}$ feet long, seven-eighths ($\frac{7}{8}$) of an inch diameter is to be driven through the head of each tie, passing down through the course on which it rests, the block and course under it, and 4 inches into the head of the next cross tie.

LONGITUDINAL TIMBERS—of flatted pine are to be carried up between the alternate courses of like dimensions, be framed, notched into the cross ties, and secured generally as described for those in the cribs.

BINDING PIECES—of 4″ x 10 inches pine plank are to be placed vertically inside for the entire height, and fastened with spikes, five-eighths ($\frac{5}{8}$) of an inch diameter, 10 inches long, one at every crossing of a face timber. They are to be not more than 14 feet apart, and are in every case to form continuations of the respective ranges underneath.

STRINGERS.—To form bearings for the top covering, five stringers, each 7 x 10 inches, of pine, are to be laid the whole length of that part of the pier, secured to the cross ties, and placed at a like height as the bottom of the rebate made in the top tier of side timbers.

The whole interior of the superstructure must be filled with a good class of stone, carried up as the timber work proceeds, and care taken to pack them well around and between the ties, as well as to have the top part properly levelled.

TOP COVERING—to be 3-inch pine plank of sufficient length to fill the rebate, or to pass over the side timbers and meet on the centre stringer. They are to be laid crosswise, one inch apart, and be fastened at the ends and at every crossing of a ringer, with 7-inch pressed spikes.

If directed, the covering is to be further secured by chamfered cap-pieces of white oak or rock elm, each 10″ x 6 inches, one range laid along each side of the pier and another in the centre over the joinings of the plank. The cap-pieces to be fastened with rag-bolts, three-fourths ($\frac{3}{4}$) of an inch diameter and 18 inches long.

The superstructure of this portion of the pier is, at the lower end, to be returned, and a proper connection made between it and the adjoining masonry.

At the upper end of the pier a sloping ice breaker is to be formed, the bottom width of which is to be about 90 feet. It is to be made to stand 15 feet further up stream in

the centre than at the sides, or it may be made so that the landward side will stand 20 feet or more beyond the outer side, or that next the river. The top of it on the front and rear side of the pier, and the upper end, formed in two divisions, each inclining outwards from the centre, are all to be made with a slope of about three horizontal to one vertical, from a point, as nearly as possible, *four* feet below the water line upwards to the top of the pier. It will be made crowning in the centre of each of the two middle divisions, and covered longitudinally on all sides with oak timber 13 inches in depth, except for 3½ feet at the angles between the different divisions, where the timbers must be at least 16 inches in depth.

The covering to be laid close throughout if so directed, otherwise it may be laid to open joints with blocks at the bearings, fastened horizontally at the time when the work is in progress. In either case the timbers must be well-fastened to the cross ties and bearing timbers under them, with screw-bolts and rag-bolts alternately, and be further secured by such straps and bands of wrought iron as may be required. The whole to be trimmed to a fair surface on top, and everything done that may be necessary to guard against any direct resistance to the action of ice brought down by the current.

In case it should be determined to put mooring posts in this portion of the pier, they are to be of white oak or rock elm timber, 10 feet long and 16 inches diameter, properly dressed, covered on top with cast iron cap-pieces, and placed so as to stand 18 inches over the top covering. They are to be notched at bottom to receive cross pieces 5 feet long, be secured to the cross ties with screw-bolts of 1¼-inch round iron, and have the ballast around them properly packed.

The outer faces of the superstructure from the top to low-water line must be hewn down neatly to lines corresponding to the position of the work, and everything done that is necessary to leave the whole in a finished and satisfactory condition.

Double Pier Works, etc.

From the bank of the river upwards to Station No. 415, or to the lower end of the solid pier, there are to be, as before stated, two ranges of crib work each 15 feet in width, placed parallel so as to leave between them a clear space of six feet.

The cribs of both these lines are to be of a like class of material and workmanship, fastened and secured in every respect in a similar manner as before described for the solid or 30 feet wide cribs, except that there will be no longitudinal ties in those 15 feet in width, and that the only bottoms in them will be cross ties, four of which are to be dovetailed into the first course of side timbers, and four into the second, so divided between the end timbers, in each case, that on looking down at both sets of ties, the nine clear vertical spaces inside of a crib 30 feet long will be about equal.

In all the other courses of timber the cross ties are to be framed, placed and secured as described for those in the 30-feet crib work. But in order to strengthen the two lower side timbers, there are to be four additional binding pieces, each four feet long, in every crib, put on and spiked to the lower side timbers and to the three others immediately above them, *i.e.*, one about mid-way between each of the end and centre binders previously mentioned.

Parties tendering should bear in mind that the contractor for this section will be called upon as the works proceed to remove boulder stone and irregularities of the bottom, not only from the space to be occupied by the cribs, as provided for the "solid" part of the pier, but that he must also remove all boulder stone and such sand as may be found on the bottom of the space between the two lines of cribs.

It should further be distinctly understood that the proper clearing of the sites for the piers and puddle bed being considered an essential part of the work, its due performance will be insisted upon, and also that the bottoms of the different cribs shall be adapted to the respective places they are to occupy when sunk, so that when settled in their position the sides and ends of them shall be plumb.

The ends of the cross ties next the puddle bed must in all cases be trimmed off fair with the sides, and the cribs be invariably sunk to bottom by means of a loaded platform on top before the ballast is put into them, which must in all cases be of an approved kind of moderate-sized stone, closely packed.

On this part of the pier the sides are to be made of an uniform height of *ten* feet over the mitre sills of the present guard lock; but in the top tier there are to be no cross ties except those that are dovetailed half their thickness into the under side of it.

To support the top of the sheet piles, the inside line of each range of cribs is to be raised from two and a half to three feet higher by means of timbers placed horizontally, fastened by bolts to those underneath, and kept in place by oblique braces extending from near the outer end of the cross ties to the top timbers.

SHEET PILES.—On each side of the puddle chamber there will be a double range of sheet piles, formed either of two courses of two-inch pine plank or of one course of two-inch plank, battened with boards one inch thick, as may be found most suitable.

They must be of uniform thickness and straight, so that the two ranges which come together may fit close to each other, and if directed the edges of the planks must be rejointed before they are used in the work. When putting them in place, care must be taken that where two cribs connect, the plank of the first tier shall extend at least four inches on each side of that place; the second tier of plank must also lap at least four inches over the vertical joints between those first put on, and they must all be driven up to as close joints as possible.

When the surface of the rock which forms the bottom of the chamber is clear, the lower end of the piles must be fitted to it as closely as circumstances will admit. At places where the bottom is clay, the lower outer edge of the plank must be cut off obliquely, made slightly pointed towards the edge where the joint is intended to be formed and then driven as far into the clay as possible.

The top of the piling to be 13 feet over the mitre sill of present guard lock, and the whole to be fastened to the upper timber of the cribs with pressed spike 6 inches long, two through the upper end of each plank. When placing the piling it must be kept such a distance in advance of the puddle as required by the officer in charge.

The planks used for the purpose above mentioned must be sound, free from checks, rot, unsound knots and other defects; but it is not necessary that they should be of the best quality.

PUDDLE.—The space between the cribs must be filled with the best description of clay for making a water-tight bank that can be obtained within a distance of one mile and a half, by land carriage, from the place where it is to be used, or within any distance from three to fifteen miles by water, or by water and land carriage combined.

The material, before it is used, must be watered, any dry lumps broken; it must also be cut and trodden or otherwise made into an improved kind of puddle, which, when packed in the chamber and made of the full height, will form a wall impervious to water.

The price tendered for puddle must include the cost of procuring and purchasing the material, hauling or otherwise transporting it, labor of handling and making it into puddle, placing it in the work, and doing everything that may be required to effect the object contemplated in the best and most efficient manner.

The height to which the puddle wall is, in the first instance, to be carried (13 feet over the mitre sill of the guard lock), will not, however, be sufficient to keep out the river when the north waters come down, about the latter end of May or early part of June, especially at a time when the River St. Lawrence is high. It may, therefore, become necessary to raise it (the puddle bed) from two to three feet higher, after having put in another short range of sheet piling on the outer side, or it may be on both sides, or of adopting such other plan as may be approved by the engineer in charge.

A puddle wall in continuation of that formed between the piers is to be made in the river bank at the lower end of the section, for such a distance as may be found necessary to prevent the water entering at that place.

PUDDLE WALL OUTSIDE OF PRESENT PIER, ETC.

To guard as much as possible against leakage through the present pier, a puddle wall is to be formed in rear of it from near the lower end of the section up to a point opposite Station No. 415.

In order to do this efficiently, all the stones that have fallen out of the old work or otherwise accumulated at the back of it must be removed, either by lifting them or dragging them outwards, so as to leave a clear space of twenty five feet in width adjoining the pier.

The seat for the puddle wall or a space of six feet in width next the old structure must be thoroughly cleared, not only of loose stones, but all rubbish, sand or whatever would be likely to prevent the connection with the bottom being water-tight.

To form a chamber for the puddle, a line of continuous crib work will be sunk between the points above mentioned, leaving a space of six feet betwixt it and the old work.

CRIB WORK—to be 12 feet in width, carried to a height corresponding to about 9 feet water on the guard lock mitre sill. The sides of the cribs may be of timber 11 inches square; the end timbers and cross ties may be 10 inches square.

They are to be built in a strong and substantial manner, but of open work, *i.e.*, the ends and sides—the ties and sides are to be notched on and into each other, and the whole fastened together with wrought iron spikes five-eighths of an inch diameter. The cross ties may be put in mid-way between those in the courses under and over them, or they may be placed directly over each other, if directed at the time when the works are in progress; but in either case binders 3 x 10 inches are to be fastened from the inside with 7-inch pressed spike, two driven through each plank into the lowest side pieces, and one at every crossing of a side timber from the floor upwards. There are to be six ranges of binders in a crib 30 feet in length, placed as previously described for those in the pier work.

The ballast floor in each crib is to be formed of the tie timbers, arranged as described for the 15 feet cribs in the double pier. The spikes used at the ends of the ties and angles of cribs will generally be sixteen inches long and five-eighths ($\frac{5}{8}$) of an inch diameter.

In all cases the bottom of each crib must be adapted to the place it is to occupy when sunk, so that the side of the puddle chamber may be plumb and the end of the cribs be as close together as possible.

They must first be sunk by means of a loaded platform on top, and when fairly resting on the bottom, they are either to be filled with stone ballast or such a quantity of it put into them as may be directed.

The side next the puddle-chamber is to be carried four feet higher than other parts of the cribs, or to 13 feet over the mitre sill of the guard lock. This may be done by means of two ranges of horizontal timbers with blocks between them supported by vertical posts, and by braces extending diagonally from near the outer end of the cross ties to the top of the posts, or in such other efficient but simple way as the contemplated object can be satisfactorily accomplished.

Where necessary, pieces of timber or scantling are to be fastened on the face of the old pier, at such places and of such dimensions as may be required to form bearings for the sheet piles. A horizontal timber, to support the top of the piles, is also to be laid at the height found to be most suitable; it is to rest on blocks, and be kept in place by means of braces connected with the wall which forms the superstructure of the old pier.

A double range of sheet piles is to be put in on both sides of the puddle chamber; they are to be of a like kind, placed, scribed to the bottom, driven where possible, fastened, and all the work connected with them done in a similar way as before described for those in the new work.

Material of a like description for puddle must also be procured, hauled, prepared packed into the chamber, carried to a like height, and as a whole be made in a similar way as provided for that to be used in the double pier.

A puddle wall must also be extended into the bank at the lower end of the section for such a distance as may be found necessary, and every precaution adopted to keep out the water during the prosecution of the works.

In case of high water in the river, the whole extent of the puddle wall is to be raised to a like height and in a similar manner as described for that in the new work; but in both cases under the conditions subsequently referred to in this specification.

The puddle walls formed on the south-eastern and north-western sides of the new basin are to be connected directly by a cross wall of puddle, carried up between two lines of crib work, built and sunk six feet apart for that purpose, and placed near to station No. 415.

By the construction of this cross-dam, in the first instance, it is probable that the direction of the current in its vicinity may be so changed as to leave an extent of still water above and below it that will admit of the lower part of the work, at least, being proceeded with in a way fully as advantageous as any that could, under the circumstances, be readily adopted.

The cribs of both ranges are to be 15 feet in width at the outer end, gradually diminishing to 12 feet in width at the inner end or place where they connect with the present pier and cribs in rear of it.

They are to be of open work, end timbers and ties notched on to the side timbers, fastened with bolts and inside binders, and as a whole built in a similar manner as above

described for those intended to form the south-easterly side of the puddle chamber at back of the old pier.

The seats for them must be cleared of all boulders or loose stone, and the space for the puddle wall between them must be thoroughly cleaned, as provided for in other cases. The bottom of each crib must be made to suit the position it is to occupy, and be sunk to its full bearings by means of a loaded platform on top, before any ballast is put into it. The cribs forming the sides of this dam are to be carried to the height of 11 feet or more, if directed, over the mitre sill of the guard lock, sheet piling on both sides of the puddle chamber to be of a like class, placed, fitted, driven and fastened as stated for the side lines. Puddle must also be provided, prepared, packed and carried to such a height as may be required, and great care taken that the puddle chamber for its full width connects properly with those formed on both sides of the basin.

In case it becomes necessary to carry the sheet piling and puddle wall higher than above stated, it is to be done either by raising the crib work, or in a similar way as provided for the side lines.

Parties tendering should bear in mind that the whole of the water within the area inclosed by the dams above mentioned will have to be pumped out, and that even in the event of more than ordinary success in preventing water entering laterally, there will still, in all probability, be a good deal of it to contend with, from its passing, "under a head," through seams and fissures in the bottom.

It is therefore quite likely that a considerable amount of pumping power will be required before the space within the exterior dams, or even any great extent of it can be laid sufficiently dry to admit of excavating the bottom parts of the channel.

It may be further observed that it is not improbable that before the object can be effected, the "head of water" will have to be divided by means of two or more interior dams, and the use of at least as many efficient engines and pumps as there may be divisions.

Contractors should therefore keep these facts in view when offering to execute the works, as the bulk sum tendered for unwatering must include the cost of constructing any and all interior, cross or longitudinal dams that the engineer in charge may consider it necessary to build for the purpose of facilitating the unwatering of the works. It must also embrace the proper maintenance of all the exterior dams above mentioned, the providing, fitting up and working all machinery and pumps that may be required for the purpose stated, also their full and proper maintenance during the whole time it may be found necessary to fully carry out and complete all the works connected with the formation of the entrance channel and basin, as contemplated in this specification. It should also be distinctly understood that the removal of all snow and ice, and every expense directly or indirectly connected with unwatering the different parts of the work on the section, below Station No. 415, must be embraced in the bulk sum stated in the tender.

The channel, as before stated, is to be made 200 feet in width at bottom, and sunk to an uniform depth of 6 feet below the top of the mitre sills of the guard lock, or to a greater depth if rendered necessary by the thickness of the stratum of rock that has to be removed. Its position will be marked out by the officer in charge; but for the most part its south-eastern line, at the surface of the rock, when about three feet over the datum line above mentioned, will be within 15 inches of the inner side of the line of crib work which forms the base of the pier.

The principal part of the excavation for the channel is rock, through which the side slopes will generally be one-quarter horizontal to one vertical.

The material over-lying the rock at the lower end of the section, consisting of clay, quarry refuse, boulder stone, etc., may be used for filling in between the crib work and spoil bank formed on the outer or river side of the line. The rock excavated there, as well as on other parts of the section, must be hauled, raised and used for a like purpose, as well as for extending the bank behind the pier beyond the point reached by the excavation hauled from Section No. 10, otherwise it is to be used for raising the bank on and behind the pier where required, or for raising the middle part of the superstructure from Station No. 415 upwards, as may be directed.

Any stone suitable for building purposes, found in the excavation, may be reserved by the contractor, for the wall to be built along the front side of the pier, or for places where walls are required on the outer or river side.

It is to be clearly understood that the works connected with the formation of the channel shall be conducted in such a manner as to guard against disturbing any of the puddle walls or piers alongside of them. To be certain that a course of this kind will be followed, the contractor must, in the first instance, form a face or cutting to the full depth, parallel to the centre line of the channel, and must continue to have such a cut at least one hundred feet in advance of the sides, before blasting at any time is done within a distance of 20 feet of the pier. When work is in this shape the space between the side of the cut and pier may be gradually diminished by means of light blasts, until the face of the rock at the top is within 15 inches of the side of the pier; it is then to be made as nearly as possible to the slope above mentioned, care being taken that all sharp, angular points are broken off, and the side trimmed to a moderately fair surface.

The slope on the north-westerly side of the channel must be trimmed in like manner, to a line corresponding to that marked out by the officer in charge.

On the projection of the rock beyond the face of the crib work, a range of timber 15 inches square, or of such other dimensions as may be required, is to be fitted and fastened with bolts of the size, made and arranged as directed, at the time the work is progress.

SUPERSTRUCTURE.—From the lower end of the section up to Station No. 434, the superstructure is to be of stones, carried to a like height as the present pier, and in the manner herein described.

The side next the channel is to consist of a wall of masonry, laid in cement mortar, started on the top of the cribs at about 6 inches back from their front edge. Before it is commenced, however, the ballast for six feet in width along the front side of the different cribs must be well packed and beaten down, at a height to admit of a continuous tier of large flat-bedded stones being laid at the same height as the front timbers of the cribs, and do whatever may be requisite to form as good a bearing surface for the wall as can be done under the circumstances.

The wall is to be five feet eight inches wide at bottom, carried up plumb in the rear, and to a batter of four inches to the foot rise on the front side. The face to be of stones, laid upon their beds in regular courses, which may vary from 8 to 16 inches in height, the highest being at the bottom, and a course once commenced must be continued at the same height throughout, or for such distance as may be approved. All the face stones to have an area of bed of at least 6 square feet, and generally be laid with their greatest length or depth inwards; their faces are to be hammered straight and square, so that the

batter can be formed by offsets on the different courses. The coping course to be at least 10 inches in height, 3 feet in width, and generally not less than 3 feet length of face, picked or scabbled so as to lay to close joints and present a fair, uniform surface on top. The backing to be of large well-shaped stones, and they, as well as the face work, must be laid in a satisfactory manner, in full beds of hydraulic cement mortar, and so as to break joints properly over and with each other.

The joints in the different courses must be grouted up as the work progresses, and everything done that may be necessary to make the wall of the best description of undressed, coursed masonry.

Contractors will doubtless observe that the face wall below Station No. 415 cannot be built until after that part of the puddle wall over the double range of crib work can be dispensed with, which it is probable will not be the case until after the month of June, in the year 1878.

It will then be necessary to take off the horizontal timbers and braces that support the upper part of the sheet piling, and remove as much of the puddle wall as will admit of connecting the two ranges of cribs by means of tie timbers. The latter are to be put in about ten feet apart, be dovetailed into the inner side timbers of both ranges of cribs, and fastened to them and the top tiers of cross ties with two-inch tree-nails, or with bolts, as may be directed.

MORTAR.—The whole masonry of the wall on the channel side of the pier must be laid in mortar made of the best hydraulic cement, mixed with clean, large-grained, sharp sand, generally in the proportion of two of sand to one of cement; or in such other proportions as may be directed.

The cement must be of approved quality, fresh from the manufactory, and, until used, must be protected from the influence of the weather in suitable buildings provided by the contractor. Mortar to be made only in such quantities as required for immediate use, and it must be prepared under the direction and to the satisfaction of the officer in charge.

Grout shall be made either by adding a sufficient quantity of water to well-tempered rich mortar, or by using about 1½ of clean, sharp sand to one of cement, and adding as much water as may be required to make the whole run freely when properly mixed.

The sand to be used for mortar or otherwise, if considered necessary, must be washed.

From the upper end of the bank formed on the river side of the pier to Station No. 434, the outer or river face of the superstructure is to be of masonry, laid dry, but in all other respects it is to be similar to that above described for the channel face of the pier.

Between the side walls above mentioned, as well as on the top of the double pier, the hearting or filling of the superstructure must consist chiefly of large-sized stones, placed horizontally on their broadest beds, arranged to lie as close together as their shape will admit of, and have all the opening or spaces between them carefully and closely packed by hand. When carried to the required height, the top is to be covered with 10 inches in depth of broken stone, such as used for macadamizing a properly constructed road. The stone, when in place, to be rolled or pounded with a heavy hammer.

Mooring posts are to be placed in the stone work part of the pier, 200 feet apart, of a like height, dimensions and class as previously described, except that they are to have a double set of cross pieces, but no screw-bolts for them will be required.

An examination of the general plan shews that to make the channel the full, clear width contemplated, namely 200 feet at Station No. 415, increasing gradually to 300 feet opposite Station No. 430, there are a few places where excavation must be done above that part of the section which it is proposed to unwater.

The first of these places, in ascending order, is in the vicinity of Station No. 417, on the north side of the line; the next is on the south side, near Station No. 421; but by far the largest is on the north side, between Stations Nos. 428 and 431, which, together with the removal of any boulders and the deepening of such small places as may be found necessary to obtain the full depth of six feet below the mitre sill of the guard lock, forms a class of excavation that must be done under water.

Attention is especially invited to these matters, at this time, so that contractors may look carefully into them, and with a knowledge of the facts, be enabled to determine for themselves the value of the work to be done.

The material excavated or taken out for the deepening of this part of the basin may be used in the cribs or for filling in the superstructure, or it may be placed outside of the pier, as found most convenient.

It is to be clearly and distinctly understood that the whole of the excavation to be done on this section (No. 11) will be measured, computed and paid for in the "solid." For this purpose, before the work is commenced, levels will be taken of that portion of the ground to be removed over the water surface, and when the space within the dams shall have been unwatered, accurate levels will be taken over the whole space to be deepened for the channel; and for the under-water work above the cross dam, correct soundings will be taken at short distances apart over the area to be deepened, in all cases with reference to fixed and permanent bench marks.

A duplicate copy of the cross sections made from these levels and soundings is to remain in the office of the Department of Public Works, another in the office of the Resident Engineer, and from these, together with levels and soundings taken after the respective parts have been completed, will be computed the quantities of excavation and work done, for which payment will be made.

There are only to be two classes or denominations of excavation recognized, namely, "earth" and "rock," the former to embrace all kinds of materials found in the old spoil bank at the lower end of the section and at all other places upon it, except absolutely connected "quarry rock" and detached stone or boulders containing one-third of a cubic yard and upwards.

The prices tendered for those items to cover the entire cost of removing the material, lifting, hauling and placing them so as to make up and extend the bank in rear of the double range of cribs (these places being looked upon and considered as the deposit or spoil ground for the section) as previously stated, and do everything connected with the excavation of the section in a workmanlike and satisfactory manner, agreeably to the foregoing specification.

But as the price per cubic yard for each class of work will be an average of the whole of that class, payments will only be made according to the comparative value of the work done with reference to the prices tendered, which *pro rata* rates shall be assigned

and apportioned in such a manner that when the whole work shall have been executed and completed the aggregate amount shall be the same as when the respective total quantities are calculated at the prices stated in the contract.

It is further to be distinctly understood that payments in the progress estimates on all other items will in like manner be made according to the comparative value of the work done with direct reference to the prices tendered.

All the stones required for filling the cribs and for the walls which are to form the front and rear sides of the superstructure of the pier must be provided by and at the expense of the contractor. The price tendered for the different items of stone must therefore cover the entire cost of procuring, hauling, transporting and placing in the work all the stone required for each and all the different purposes mentioned and contemplated in this specification.

The Department of Public Works may, however, allow the contractor for this section to take such stones for ballasting the crib work as can be obtained from the spoil banks on Section No. 9, provided he removes them without interrupting or interfering with the operations of other contractors; but he (the contractor for Section No. 11) will not be permitted to load stone or scows or other craft in the canal or any part of Sections Nos. 9 or 10 or at any place likely to interrupt the passage of vessels.

In all matters connected with the prosecution of the works, the transportation and delivery of materials of any kind required for them, or in the arrangements for carrying on the operations of deepening the channel, or of the disposal of the excavated material, or in proceeding with any part of the operations connected with the works, the contractor must be governed by the canal regulations and the interpretation put upon them by the officer entrusted with that duty; he must further use every precaution to guard against interrupting, impeding or in any way interfering with the navigation, as he will be held strictly and legally liable for all damage, loss or detention that any vessel, when passing through the canal, may sustain from any of his acts, whether such result from a desire to prosecute the works, inattention or any other cause.

The different works herein described or enumerated are to be proceeded with at the time and in the order required by the Department of Public Works, all of which must be executed agreeably to the plan contemplated in this specification and the direction of the officer in immediate charge, although all that may be required to complete the design may not have been particularly described.

DETAILED PLANS.—The plans exhibited are only intended to show the contemplated arrangements and general mode of construction, but detailed working drawings, arranged, modified and adapted to the locality and for all such parts of the structures as may be required will be furnished as the works proceed.

The contractor must provide, at his own cost and expense, all the service ground that may be required for the purpose of placing and preparing materials, or for the erection of sheds, storehouses or any other buildings, or for temporary roads, or for any other purpose whatsoever.

He must also provide and deliver, at his own cost, all necessary materials, and furnish all plant, tools, vessels, machinery, equipments, labor and everything necessary for the satisfactory execution and completion of the different works contemplated in the foregoing specification.

All the materials used in the works must be of the best class of their respective kinds, and the prices tendered for the several items of work must cover the entire cost of their purchase, delivery, workmanship and every contingency connected with the due prosecution of the different works as herein described, and the instructions that may from time to time be given by the engineer or other authorized officer.

Tenders will not be considered unless made strictly in accordance with the printed forms and—in the case of firms—except there are attached the actual signature, the nature of the occupation and place of residence of each member of the same.

For the fulfilment of the contract, satisfactory security will be required on real estate or by deposit of money, public or municipal securities, or bank stocks, to an amount of *five per cent.* on the bulk sum of the contract.

Ninety per cent. only of the progress estimates will be paid until the completion of the work.

To each tender must be attached the actual signatures of two responsible and solvent persons, residents of the Dominion, willing to become sureties for the carrying out of these conditions, as well as for the due performance of the works embraced in the contract.

The works are to be commenced immediately after the person or persons whose tender has been accepted shall have entered into contract, and must be proceeded with in such a manner as to fully satisfy the Department of Public Works that the whole of the works embraced in the contract can be fully completed on or before the twenty fifth day of April, 1879.

JOHN PAGE,
Chief Engineer of Public Works.

OTTAWA, 4th March, 1876.

APPENDIX No. 47.

Lachine, November 28th, 1879.

JOHN PAGE, Esq.,
Chief Engineer of Public Works,

SIR,

In compliance with instructions received from you, I submit the following General Report upon that portion of the works of the Lachine Canal enlargement under my charge.

This comprises the four upper sections, viz.: Sections Nos. 8, 9, 10, and 11.

SECTION No. 8.

The work upon this section consists of the enlargement of the prism of the old canal to a width, at mean depth, of one hundred and fifty feet, and to a depth suitable to a navigation of twelve feet; the protection of the earth sides of the prism by walls; the forming on the north side of the canal of a tow path, and on the south side of a berme bank; the building of culverts where necessary, to provide for the natural drainage of lands adjoining the canal; the grading and ditching of a public road for a distance of four thousand one hundred (4,100) feet along the south bank of the canal, to replace one which had formerly existed on that side of the old canal; and lastly, the construction of a puddle bank for a distance of fourteen hundred and ninety-two feet (1,492) on the north side, to make water-tight the old bank where it had been cut away, in enlarging the prism, to such an extent as to cause leakage.

To provide for a navigation of twelve (12) feet, the prism has been deepened to an extent which gives thirteen (13) feet of water at the lowest stage of the river. The slopes in earth are made to suit the class of wall used to protect them, being either with a base of one to a vertical height of one also, or nearly vertical. In rock a slope of one-fourth horizontal to one vertical has been adopted. The mean width of one hundred and fifty (150) feet remains constant.

The side walls, where their vertical height does not exceed seven (7) feet, are built dry, with a face batter of three inches to the foot, being plumb in rear and two (2) feet thick at top. The best and largest stones found in excavation are used for this purpose.

Where a vertical height of seven (7) feet is exceeded, a dry rip-rap wall has been built, face slope at an angle of forty-five (45) degrees, the width on top being twenty (20) inches, increasing downwards at the rate of .0033 inches per foot. This gives a bottom width where the wall is of full height of thirty two (32) inches. At the mouth of culverts these slope walls are laid in cement, from base to water level, and for a width of about twenty four feet. When founded on rock a toe timber is placed and securely fixed with bolts 20" x 1" round iron; when founded in earth, a trench is prepared of a V shape, to suit the base of the wall, which is placed at an elevation sufficiently low to admit of the future deepening of the canal to the extent of two (2) feet.

The tow path formed on the north side of the canal has a clear width of eighteen (18) feet, and stands eighteen (18) feet above the bottom of the canal (as now enlarged) with a slope outwards of one (1) foot. In cutting, the tow path is provided with a ditch in rear four (4) feet wide at top, and the slopes in earth are made two horizontal to one vertical. In rock, the slopes are made as nearly one-fourth horizontal to one vertical as practicable.

The berme bank formed on the south side of the canal is twelve (12) feet in clear width, and stands one foot higher than the tow path. In other respects it is constructed in a manner exactly similar to the tow path above described.

Culverts have been placed where required for the natural drainage, as well as to receive the water from the side ditches. With one exception they consist of box drains, two feet square in the clear, with wells at upper end three feet square and sunk two feet below the bottom of the box. They are founded on slabs or paving stones, and built of stone procured on the section, laid in cement. The covering is of stone. There are thirteen (13) of these culverts, besides one beam culvert of six (6) feet opening, covered with timber, with masonry of the same class as that used in the box culverts already described.

The public road has been ditched for nearly its whole length on the south side only; drainage on the north side being provided by the ditch of the berme bank. It has been graded throughout for a width of thirty (30) feet. Under the superintendence of Mr. Conway, Superintendent of the Lachine Canal, it has also been macadamized for a width of twelve (12) feet.

The puddle bank has been formed in the old bank of the canal by excavating a trench until solid and impervious material has been reached. This has then been filled with puddle clay to a height of about one foot above the highest water in the canal. Owing to the necessity for this work being done during the season of navigation, a large expense was incurred in unwatering.

Excavation in the prism consists of earth and rock, the latter comprising boulders and loose rock of one-third cubic yard and upwards, as well as solid quarry rock. In the side work and puddle bank the excavation was entirely in earth, the rock encountered being only boulders and loose rock.

The contract for this section was signed March 20th, 1876, by Messrs. O'Brien, Sullivan & Shanly.

Work was commenced July 17th of the same year, and during the summer season the greater part of earth excavation above water was completed, and public road partly graded. Two dredges also worked for a short time.

During the winter of 1877 a large force was employed in earth and rock excavation, and a small portion of the sides was walled. During the summer, dredges were again employed, and some of the culverts were built.

The operations during the winter of 1878 consisted of the completion of nearly all rock and earth excavation in prism, and the building thirteen thousand three hundred and fifty five (13,355) lineal feet of side walling; and during the ensuing summer a little dredging was done. Culverts and public road were completed and repairs were made in old canal bank by the construction of the puddle bank. On the 7th December of this year all operations ceased.

May 4th, 1879, all work in the prism was finished, and during that month all side work was trimmed up, and work upon the section generally completed.

The amount of work done upon this section for each year is shown in the following table:—

Date.	Earthwork.	Rock Excavation.	Puddle.	Wall Masonry.	Culvert Masonry.
1877.....	100,986	23,626	—	1,365	220
1878.....	89,254	94,949	2,589	20,788	222
1879.....	28,297	13,354	2,215	3,749	26
Totals ...	218,537	131,929	4,804	25,902	468

The length of this section is seven thousand five hundred and forty three (7,543) feet.

Section No. 9.

The work upon this section comprises the widening and deepening of the prism of the old canal to the same extent, generally, as already described for Section No. 8. At the upper end of the section, however, where a diversion is made from the course of the old canal, the width of one hundred and fifty feet is increased:—the protecting of the sides of the prism, in earth, by walls; the forming of a tow path on the north side, and of a berme bank on the south side; the building of the necessary culverts and off-take drains, and the placing of a small quantity of puddle at two places where leaks had existed in the bank of the old canal.

In the prism, the slopes in earth are made as nearly vertical as possible, to suit the style of wall used for protecting them, while in rock they are made with a base of one-quarter to one of vertical height.

The walls protecting the sides of the prism are built of masonry, laid dry. They are vertical at rear with a face batir of either two or three inches per foot. The width on top is two feet, increased to three feet where the vertical height exceeds about eight feet. Where considered necessary, the stability of these walls has been increased by the addition of a frost batir of one foot. When in earth, the foundation has been placed at such a depth as to allow of a further deepening of the prism to the extent of two feet. They are built of the best stone found in the excavation and the spaces behind are filled with broken stone.

The tow path on the north side and berme bank on south side of the canal stand at an elevation of eighteen (18) feet above the bottom of the prism, and are formed as those described for the preceding section.

The culverts are square box drains, built of stone and laid dry, and founded generally upon the rock. The clear opening is 18″ x 18″. The off-take drains convey the water from the back ditches under the tow path and berme bank and discharge it into the canal. They are built in the same manner as the culverts, but with openings of only one foot square. These culverts and off-take drains being based upon the rock, enter the canal at various elevations.

The puddle placed at two points to reinforce the old bank, was inconsiderable in quantity; the leaks being trifling in extent.

The original contractors for this section were Messrs. John and Patrick Lyons. Under their management, work was commenced 3rd February, 1876, and carried on until April, 1877, when an assignment of the contract was made to Mr. John Phelan, who continued the work until the 16th March, 1878, when he failed and left the country. To prepare the canal for the opening of navigation, considerable work was necessary. This was undertaken by Mr. Conway, Superintendent of the Lachine Canal, and under his supervision everything was done which was required before the letting in of the water. November 26th, 1878, operations were re-commenced under contract with the firm Williamson, Rogers & Farrell, and completed May 31st, 1879.

During the winter and spring of 1876, the greater part of the earth excavation above water was done, as well as a small quantity of rock above water. Derricks were set up and preparations made during the summer, to commence work in the prism as soon as possible after the water had been let out of the canal. New culverts were also built, and old culverts were repaired.

The operations during the winter of 1877 consisted in the excavation of a large quantity of earth and rock in prism, and the building of a large amount of wall on both sides of the canal. During the summer of this year and until November 28th, nothing was done upon this section.

During the winter of 1878 the amount of work done was small, and confined almost entirely to the lower end of the section. Fifteen hundred (1,500) feet in length of the north side was walled; and the prism for two thousand five hundred feet (2,500) was partly graded. No work was done during the time of navigation, but in the month of December a little earth excavation was done before the water was let out of the canal, and, as soon afterwards as possible, a large force was placed upon rock and earth excavation in the prism.

Throughout the winter season of 1879 the excavation and walling were pushed on with a force calculated to ensure the completion of the work below water before the opening of navigation. All work in the prism was finished May 3rd, and the water let in at 4.30 p.m. of that day. During the month of May the contractors were engaged in finishing walls above water, trimming tow-path, berme bank, ditching and putting in off-take drains, all of which was accomplished, and the section put in a finished condition on the last day of the month.

The contractors who completed this section shewed energy and skill in the manner in which they carried on their work, and deserve credit for having accomplished all that was required of them at the time of the opening of navigation.

The length of this section is five thousand nine hundred and eighty (5,980) feet.

The result of the operations of each year, ending June 30th, is shown in the following table :—

Date.	Earthwork.	Rock Excavation.	Puddle.	Wall Masonry.	Culvert Masonry.
1876....	53,785	1,024	*nil*	*nil*	*nil*
1877....	49,071	47,312	117	4,215	257
1878....	11,854	32,293	*nil*	3,227	*nil*
1879....	13,648	115,601	*nil*	7,515	*nil*
Totals....	128,358	196,230	117	14,957	257

SECTION No. 10.

The work upon this section includes the widening and deepening of a portion of the old canal to the dimensions described for the two preceding sections; the formation in part of a new channel of similar width and depth; the protection of the earth sides with walls; the forming of a tow path on the north side, and of a berme bank on the south side for a portion of the section only; the grading of the canal property on both sides at the upper end of the section; the building of the necessary culverts and drains, and the construction of a guard lock with retaining walls and bridge abutments.

The prism and sides below the lock have been formed with least width, depth and slopes, in a manner exactly similar to what has already been described for Section No. 9. The width, however, where the new canal diverges from the old work, is necessarily very much increased. The short portion of the section above the lock has been excavated to a depth giving fifteen (15) feet at lowest stage of the river, as required for a navigation of fourteen (14) feet.

The side walls are, for the greater length of the section, of masonry laid dry and built of the largest and best stones taken out of the excavation. Adjoining the lower wing walls of the lock, and in forming a continuation of the retaining walls of the bridge at the upper end of the lock, they are laid in cement. In the former case they are three (3) feet wide on top, vertical at rear, and with face batir of two inches per foot; in the latter case the width at base has been made eight feet, the batir varying from two inches to one-half inch per foot at their junction with the lock walls and bridge retaining walls, with a frost batir commencing within five feet of the top, making the width on the top three (3) feet. These walls of both classes are always founded upon the rock.

The berme bank and tow path are formed to a like height, and finished in the same manner as those described for Section No. 9.

One culvert and one drain only were built on this section, both being boxes of two feet square in clear, built of masonry, laid dry. At the upper end of this drain a well is sunk, covered in with an iron grating, which admits of the drainage of the public road which crosses the canal immediately above the lock.

The guard lock is two hundred and seventy (270) feet in length between hollow quoins and forty five (45) feet in width at bottom, with a depth on sills of fourteen (14) feet at lowest stage of water in the river. This lock is provided with the necessary recesses, and anchor wall required for the placing of a guard gate above the upper pair of gates. Above the guard gate recesses the lock walls are extended, forming retaining

walls for the bridge abutments, which are placed at a sufficient distance to allow of the bridge swinging towards the lock, instead of away from it, as is the case at the present lock at Lachine. The foundation of this lock, although in rock, was not considered sufficiently reliable, and a timber foundation with two courses of planking was prepared. The sills are placed at a depth of five feet below these of the old guard lock at Lachine. The only variation from the terms of the specification occurs in the timbers in the lock chamber having been allowed of shorter lengths than those called for ; they extend, however, at least three (3) feet under the lock walls. The stone used in the construction of the lock and bridge masonry was all of an approved quality ; that used for the face work was obtained chiefly at Isle Le Mothe, a small quantity only having been obtained in the vicinity of the work. The stone used for backing was brought from quarries at St. Geneviève and Caughnawaga. In all cases it is a grey limestone.

The contract for this section was signed January 12th, 1876, by the firm Rogers, Kelly and Co.

Work was commenced on February 3rd of the same year, and during the winter months operations were confined to excavation in earth.

During the year ending June 30th, 1877, a large proportion of the earth and rock excavation was done. Arrangements were made for the delivery of cut stone, and materials of different kinds were delivered. A portion of the culvert masonry was also built.

The work done during the year ending June 30th, 1878, comprised the removal of earth and rock, the building of side walls, and putting in of timber foundation for lock. One mitre sill was also placed and another framed. A quantity of stone for lock masonry was also cut, and derricks erected for laying lock walls.

August 5th, 1878, masonry in the lock was commenced and was continued until November 17th. At the completion of the fiscal year all the lock masonry, as well as the greater part of the bridge and side wall masonry had been completed, the tow path and berme bank, together with the ground south of the lock, graded and ditched and the culverts completed.

During the months of July, August, September and October, the bridge masonry and masonry in side walls was finished, the remaining rock and earth adjoining Section No. 11 was removed, the south approach to swing bridge was graded and macadamized, and the ground between the old and new locks was levelled up.

Nothing remains now to be done, with exception of the grading of north approach to the bridge.

All materials removed from excavation in the lock pit and section generally, excepting only the clay reserved for puddling behind the lock walls, and other earth required for finishing up, has been deposited in the river. An embankment has thus been formed extending up stream for a distance of four thousand eight hundred (4,800) feet, following the line of pier on Section No. 11, and forming a complete protection to it for this portion of its length.

The length of this section is fourteen hundred and eight feet.

The table below shows the total amount of the principal items of work done during each fiscal year, ending June 30th.

Date.	Excavation.		Masonry.				Concrete	Puddle	Filling behind Walls	Timber.		Plank	Iron.
	Earth	Rock	Lock	Bridge	Side Walls	Culverts							
	C yds.	C yds.	C yds.	C yds.	C yds.	C yds.	C yds	C yds.	C yds.	C feet.	C feet.	F.B.M.	Lbs.
1876	22,765	86	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.
1877	30,419	39,020	"	"	"	169	"	"	"	"	"	"	"
1878	2,237	35,214	"	"	2,402	32	259	"	"	473	5,945	"	"
1879	2,681	8,313	7,055	1,717	1,426	118	1,885	887	2,766	589	9,394	96,623	26,584
1879	494	356	100	90	157	nil.	nil.	nil.	nil.	nil.	nil.	nil.	471
	58,596	82,998	7,155	1,807	3,985	319	2,144	887	2,766	1,062	15,339	96,623	27,055

Section No. 11.

The work upon this section comprises the construction of a new entrance to the canal at Lachine. This amounts to the formation of an entirely new harbor. This, when completed, will be formed by a continuous line of pier extending up stream for a distance of six thousand one hundred feet.

The harbour, when completed, will be formed by a continuous line of pier placed on the river side of the old pier, and following nearly the same direction.

The channel will be generally two hundred feet in width. At the upper end of the section this width will be increased to three hundred feet. The depth throughout will be fifteen (15) feet at the lowest stage of water in the river.

On the north side the channel will be marked by a number of detached cribs.

The excavation consists chiefly of rock; at the lower end of the section only a small quantity of earth is found.

To effect the unwatering of the section at the lower end, the pier has, for a length of three thousand six hundred (3,600) feet, been built of a double row of crib work, with a space between them of six feet. A cross dam has also been built. Above this dam all the excavation is taken out by means of submarine blasting and dredging. Below the cross dam, and dividing this part of the section into two nearly equal portions, a dam has been placed. All expense connected with this dam is borne by the contractor.

In connection with the unwatering of the section an additional expense has been incurred, owing to the spreading of the cribs of the double crib work, as well as those placed along the old pier and forming the base of the dam on that side of the work. To

stop this inclination to spread, stone was placed on top of the cribs. Before the sides are finished by the proposed wall, this stone must, in a measure, be removed. Stone was also placed at the base of the cribs to prevent their moving. The result has been satisfactory.

The pier at the upper end terminates in an ice-breaker built in the most solid manner, and sheeted with white oak, thirteen inches in thickness.

The superstructure, for a distance of six hundred feet below the ice-breaker, is of timber. Below this point, it will be of masonry on one or both sides. Above the point to which the embankment extends, a wall will be built on both sides; below that point, a wall will be built upon the north side only.

This pier, when finished, will stand at about the same height as the existing pier, and at highest flood will be probably but one foot above water.

The extent to which the water will be raised by the construction of the new pier is difficult to estimate. It must be considerable, and will probably amount to eight inches. This would make a corresponding increase in the depth of the canal throughout.

The effect of the new works will be to increase the marginal ice for a distance of about three-quarters of a mile above the head of the pier.

In every respect the specification has been carried out as strictly as possible.

The contract was signed for this section by the firm of W. Davis & Sons, March 21st, 1876, and work was commenced in the month of July of the same year.

During the year ending June 30th, 1877, work upon the pier was pushed forward and a large amount of timber was framed and put into position. A large amount of labor was also expended upon submarine excavation.

Work was carried on during the season of 1878, in all its different branches, and also during the year closed at the date of my last report.

The state of the work at present may be thus described; all crib work is finished; the small portion remaining yet to be done being insignificant. All the dams are finished and seem to be trustworthy. There seems to be no difficulty in unwatering. As the head of water increases, more trouble will in all probability be encountered. One pump only is now at work, and it seems quite equal to the work required. A second will be in running order in about ten days. With these two pumps there will be no difficulty in keeping the section dry.

Operations are confined entirely to the lower end of the section. The submarine work has been almost completed. In the amount of this work there is an excess above the estimated quantity. This is caused by the necessity for going below grade. In the returns made from month to month all submarine excavation to one foot below grade has been included. This has been carrying out an arbitrary rule. The bed of rock at grade has often exceeded three feet in thickness, and to remove this it is necessary to do a large amount of unpaying work. The foot below grade, allowed up to the present, does appear to be small to cover what has been actually taken out. In dry work the specifications admit of a return being made of rock below grade. On Sections Nos. 9 and 10 it has been found necessary to remove rock for a depth of two feet below grade. On Section No. 11 it is impossible to speak with the same certainty.

The depth of water on this section will be increased considerably by the obstruction rmed by the new works.

The work done from year to year is shewn in the table below :—

Date.	Earth Exc'tn.	Rock Exc'tn.	Submar. Excavat'n.	Puddle.	Stone Filling.	Crib Work.	Sheet Piling.	Iron.	Oak Timbers	Binders	Mas'y
876	nil.	nil.	nil.	nil.	8,869	89,159	nil.	nil.	nil.	7,066	nil
877	"	"	3,963	"	31,334	325,058	140,071	23,995	"	19,028	"
878	"	"	12,983	6,755	33,080	176,413	327,635	89,403	"	7,206	"
879	6,883	14,770	3,439	19,404	34,521	141,723	735,252	56,273	6,501	4,375	7
Total	6,883	14,770	20,385	26,159	107,804	732,353	1,203,558	237,329	6,501	37,675	7

I have the honor to be, Sir,

Your obedient servant,

H. H. KILLALY,

Resident Assistant Engineer.